DOCUMENT RESUME

ED 349 417	CE 061 889

TITLE	Tech Prep Indiana Training Manual.
INSTITUTION	Purdue Univ., Lafayette, Ind.
SPONS AGENCY	Indiana State Dept. of Education, Indianapolis.
PUB DATE	Aug 92
NOTE	665p.
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052)
EDRS PRICE	MF03/PC27 Plus Postage.
DESCRIPTORS	Articulation (Education); Competency Based Education; Course Content; *Curriculum Development; Educational Change; English; Higher Education; High Schools; Inservice Teacher Education; Institutional Cooperation; *Interdisciplinary Approach; Language Arts; Material Development; Mathematics; Postsecondary Education; *Preservice Teacher Education; Program Evaluation; *Program Implementation; Sciences; Staff Development; State Programs; *Teacher Workshops; Teaching Methods; *Technology
IDENTIFIERS	Indiana; Technology Education; *Tech Prep

ABSTRACT

This manual is designed as a training tool for individuals who are implementing tech prep in Indiana. It is divided into three major divisions. Division I contains general information about tech prep and issues related to its implementation. Its nine chapters summarize relevant legislation, address leadership concerns, explain curriculum development, describe instructional strategies, make suggestions for developing articulation agreements between secondary and postsecondary institutions, discuss issues that may impede implementation, discuss other school reform, and describe program evaluation. Division II contains suggestions for preservice teacher educators and instructional units in English/language arts, mathematics, science, and technology to illustrate the applied academics approach that characterizes tech prep. An interdisciplinary module on bar coding is included that contains abbreviated lesson plans (design briefs) dealing with technology, language arts, mathematics, and science. Division III contains suggestions and materials for conducting inservice workshops for teachers who will be implementing tech prep. Trainer and trainee material are provided for three staff development workshops on curriculum development, identifying tech prep content, and developing tech prep instructional materials. Appendixes include a list of curriculum materials for applied academics, an annotated listing of materials available from the National Tech Prep Clearinghouse, and a list of 125 references. (YLB)

****
*   Reproductions supplied by EDRS are the best that can be made   *
*   from the original document.   *
****

TECH PREP
INDIANA

ED349417

TRAINING MANUAL

Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

CE061888

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

● Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

August 1992

BEST COPY AVAILABLE

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

Training Manual Overview

STOP!

This overview contains important information about how to use this manual. Please read it before continuing.

TRAINING MANUAL OVERVIEW

Introduction

The materials in this manual are the result of efforts begun at Indiana University under the Indiana Tech Prep Teacher Training Program (Project # 90S-4762(T)) and continued at Purdue University under the Purdue Tech Prep Staff Training Project (Project # 92S-4762(TR)). Both efforts were funded by the state through the Indiana Department of Education (IDOE). Many individuals contributed to this effort over a period of several years. Some of the key individuals are named in Appendix A.

This manual was prepared as a training tool for individuals who are implementing Tech Prep in Indiana. It contains far more information than any one person will need. Some material is for Tech Prep Regional Coordinators who provide overall direction for Tech Prep within each region; other material is for teachers, counselors, administrators, and postsecondary educators who are preparing preservice teachers for Tech Prep.

Additional Resources

Since this writing effort began, two national publications have done an outstanding job of addressing important issues related to Tech Prep implementation. They are:

> Hull, D. & Parnell, D. (1991). Tech Prep associate degree: A win/win experience. Waco, TX: Center for Occupational Research and Development. (Available from Center for Occupational Research and Development (CORD), 601 C Lake Air Drive, Waco, TX 76710. Phone: 800-231-3015)
>
> Dornsife, C. (1992). Beyond articulation: The development of Tech Prep programs. Berkeley, CA: National Center for Research in Vocational Education, University of California at Berkeley. (Available from the NCRVE Materials Distribution Service, Western Illinois University, 46 Horrabin Hall, Macomb, IL 61455. Phone: 800-637-7652)

If you do not have these two publications, you should obtain them for use along with this manual. Frequent reference is made to these publications, and materials are written assuming that readers have read the first publication and have access to the second.

Organization

The manual is divided into three major divisions. **Division I** contains general information about Tech Prep and issues related to its implementation. **Division II** contains suggestions for preservice teacher educators and instructional units in English/language arts, mathematics, science, and technology to illustrate the applied academics approach that characterizes Tech Prep. **Division III** contains suggestions and materials for conducting inservice workshops for teachers who will be implementing Tech Prep.

The **Overall Table of Contents** that follows this Overview lists the contents of the entire manual. There are separate tables of contents for each division and for each module in Division II. Each major section in the tables of contents is accompanied by an abstract describing the contents of that section. By reading the abstract you should be able to identify the materials that will interest you.

This manual is organized around topics and themes addressed in Hull & Parnell (1991): What is Tech Prep? Why is it needed? What does the curriculum look like? How do you get started? Topics that are fully addressed in Hull and Parnell (1991) or in Dornsife (1992) are treated superficially or not at all in this manual. Additional information is provided when the Indiana Tech Prep initiative differs from the national effort or when the discussion in Hull and Parnell (1991) and Dornsife (1992) is incomplete.

Updating the Manual

Additional resources and information about Tech Prep are appearing on a daily basis. This manual will become dated very quickly unless it is regularly updated. You will want to collect sample flyers, newsletters, and other materials from the State Tech Prep Coordinator in the Indiana Department of Workforce Development and from the fourteen Indiana Tech Prep regional consortia. You will want to add articles from professional journals and materials distributed at workshops. You may also want to add materials from the National Tech Prep Clearinghouse of Resources which has been established to provide information about Tech Prep. Appendix C contains the latest bibliography of materials available from the Clearinghouse.

About Terms

In Hull and Parnell (1991), *TPAD* is used to refer to a *Tech Prep/Associate Degree* program--the same program that Parnell described in The Neglected Majority as *Tech Prep*. They use *tech prep* (lower case) in reference to the *secondary portion of the TPAD program*. In these materials we use *Tech Prep* (capitalized) to refer to the *TPAD program initiative in Indiana, whether the reference is to the secondary or postsecondary portion of the program*. Other terms that may have a special meaning in these materials are defined in the Glossary.

The authors hope you find these materials helpful as you work to implement Tech Prep, and they wish you the very best of luck as you work to bring about this important school reform.

Overall Table of Contents

Front Matter

Training Manual Overview

Introduction . . . iii
Additional resources . . . iii
Organization . . . iii
Updating the manual . . . iv
About terms . . . iv

Overall Table of Contents . . . v

Division I

Division I Table of Contents . . . iii

Chapter 1: Introduction to Tech Prep

Abstract. Brief overview of Tech Prep. Description of origins of Tech Prep at national and state level. Organization of Tech Prep in Indiana. Goals, including distinctive features of Indiana Model. Summary of legislation that affects Tech Prep. Recommended reading for anyone who is just learning about Tech Prep.

The National Tech Prep Movement . . . 3
Tech Prep in Indiana . . . 3
Organization . . . 5
Goals of Tech Prep . . . 5
The Indiana Tech Prep Model . . . 7
Legislative Summary . . . 7
P. L. 217-1987 . . . 9
P. L. 19-1992 . . . 12
Perkins Act . . . 16
References . . . 20

Figures

Figure 1: State Tech Prep Organization . . . 4
Figure 2: Regional Tech Prep Organization . . . 6
Figure 3: Tech Prep Curriculum Model for Indiana . . . 8

Chapter 2: Providing Leadership for Tech Prep

Abstract. Reference is made to Hull & Parnell where practical leadership issues are addressed. Indiana's legislative mandate and rationale for it are discussed before addressing what leaders need to do to move forward with Tech Prep under conditions of limited resources. Tech Prep leaders will find arguments that can help them respond to concerns within their region.

Introduction . . . 3
Legislative Mandate . . . 3

Chapter 2 (cont.)

Tech Prep has Merit 4
Moving forward with Tech Prep 6
Identifying and securing resources 6
References 9

Chapter 3: Curriculum Development for Tech Prep

Abstract. Explains three essential elements of Tech Prep curriculum: applied academics, integrated subjects, and competency based curriculum. Steps in developing the Tech Prep curriculum are explained along with levels of implementation that are unique to Tech Prep. Primarily of interest to those developing curriculum materials.

Introduction 3
Characteristics of the Tech Prep Curriculum 3
    Applied Academics 3
    Integrated Subjects 5
    Competency based Curriculum 6
Curriculum Development 8
    Review the needs of the community 8
    Review the current curricula 9
    Identify and do away with duplication 9
    Modify and develop courses as needed 9
Levels of implementation 9
    Hull and Parnell's Levels 10
    Levels of technology use 10
    Levels of collaboration 10
Table 1: Models of Integrating Vocational and Academic Education 12
Summary of models in Table 1 14
References 20

Chapter 4: Instructional Strategies for Tech Prep

Abstract. Describes instructional strategies that characterize Tech Prep. Among topics discussed are problem solving, cooperative learning, and learning styles. Of particular interest to individuals who will develop or teach Tech Prep courses.

Introduction 3
Applications based instruction 3
Learning Styles 8
Cooperative Learning 9
Problem Solving 11
References 14

Chapter 5: Articulation

Abstract. Suggestions for developing articulation agreements between secondary and postsecondary institutions.

Introduction 3
Principles of articulation 3
    Leadership and commitment 3
    Early faculty involvement 3

Chapter 5 (cont.)

- Respect and Trust 4
- Mutual benefits to all parties 4
- Written articulation agreement 4
- Open, clear, and frequent communication 4
- Modest initial goals 5
- Accountability 5
- Competency based curricula 5
- A common focus on mutual goals rather than on individual turf 5

Process of articulation 5
- Advanced placement or credit 5
- Stages of articulation 6

References 7

Chapter 6: Smoothing the Rough Spots

Abstract. Discussion of issues that may impede implementation of Tech Prep. Suggests mechanisms for dealing with the issues. Of particular interest to regional and local leaders.

Introduction 3
Teacher concerns 3
Administrative concerns 3
2+2, 4+2, 2+2+2, 4+2+2 4
Student ability levels 4
Staff development 5
References 6

Chapter 7: Economics Education for Tech Prep

Abstract. Brief description of the Indiana Council for Economic Education and how they might assist with Tech Prep curriculum development. Of particular interest to individuals responsible for curriculum development.

Introduction 3
Background on Indiana Council for Economic Education 3
Need for economic education in Tech Prep 3
An economic education/workplace literacy program 3
Attachment 1: Indiana Council for Economic Education 5
Attachment 2: Choices and Changes Curriculum Summary 7

Chapter 8: Tech Prep as Systemic School Reform

Abstract. Discussion of other school reform with emphasis on how Tech Prep fits with these other reform efforts. Of primary interest to individuals in schools already involved in another school reform effort.

In the aftermath of A Nation at Risk 3
Indiana 2000 and Tech Prep 3
Re: Learning and Tech Prep 3
SREB and Tech Prep 5
Other school reform 5
ASCD and Tech Prep 5

Chapter 8 (cont.)

- References 6
- Principles Guiding Futures Planning for Curriculum Renewal by Cawelti 7

Chapter 9: Evaluation of Tech Prep Programs

Abstract. The CIPP program evaluation model is outlined, key evaluation questions are mentioned, and evaluation methods are described. Primarily of interest to those who are responsible for program evaluation.

- Program evaluation model 3
- The CIPP model 3
    - Context evaluation 3
    - Input evaluation 4
    - Process evaluation 4
    - Product evaluation 4
- Key evaluation questions 4
- Evaluation methods 5
- The evaluation design and plan 5
    - A. Setting the stage 5
    - B. Collecting information 6
        - Initial and Post performance 6
        - Program execution 6
        - Costs 6
        - Indirect impact and attitudes 7
- References 7
- Self-Rating scale 8

DIVISION II

Division II Table of Contents iii

Division II Overview

Abstract. Discusses preservice teacher education needs for Tech Prep and provides an introduction to the five instructional modules in Division II. Of primary interest to college and university teacher educators.

- Introduction 3
- What is different about Tech Prep 3
    - Knowledge base for Tech Prep 3
    - Student base for Tech Prep 3
    - Instructional Organization for Tech Prep 3
    - Teaching strategies for Tech Prep 4
- Implications for preservice teacher education 4
    - Teaching strategies 4
    - Effect of specialization on teaching integrated subjects 5
    - Levels of collaboration 6
- Discussion of instructional modules 7
    - What the modules have in common 7

Division II (cont.)

How the modules differ 7
Who the modules are for 8
References 9

Module 1: Prototype Units in English/Language Arts

Unit 1: The Personal Job Search

Abstract. Illustrates instruction that incorporates applications based instruction, problem solving, cooperative learning, and other features of Tech Prep, but without requiring ongoing collaboration between two or more teachers. Shows how Tech Prep can be implemented in schools that are unable to establish collaboration across subject areas as a permanent part of the curriculum.

Introduction 3
Unit overview 3
General objectives 5
Instructional strategies 23
Lesson 1: Dream job writing assignment 25
Lesson 2: Occupational Cluster 26
Lesson 3: Data retrieval 27
Lesson 4: Job search 28
Lesson 5: Written communications 29
Lesson 6: Job applications 30
Lesson 7: Oral communication skills 31
Lesson 8: Interview etiquette 32
Lesson 9: Interview preparation 33
Lesson 10: Job interviews 34
Unit evaluation 35
Attachment 1: Cluster search methods 36
Attachment 2: Town & Country Homecenter job application 37
Attachment 3: R. R. Donnelley & Sons job application 39

Figures

Figure 1: Model for Goals, Proficiencies, and Objectives 4
Figure 2: A Three-Part Foundation 6
Figure 3: Five Competencies 7
Figure 4: Indiana Department of Education Language Arts Proficiencies . . 8
Figure 5: Personal Job Search Unit Objectives 9
Figure 6: Tech Prep Goals (Foundations) and Unit Objectives 10
Figure 7: Tech Prep Goals (Competencies) and Unit Objectives 14
Figure 8: Language Arts Proficiencies and Unit Objectives 18
Figure 9: Conceptual Framework for Personal Job Search 22
Figure 10: Unit Activities and Instructional Strategies 24

Module I (cont.)

Unit 2: Create-A-Product

Abstract: Illustrates instruction that involves collaboration between language arts and technology teachers. Units that involve collaboration with teachers of science, mathematics, or other disciplines could be developed along similar lines.

Introduction 3
Unit overview 4
General objectives 4
Outline for unit content 15
Instructional strategies 16
Lesson 1: Group information and brainstorming 19
Lesson 2: Warmup for product design 20
Lesson 3: Company name, letterhead, and logo 21
Lesson 4: Product description 22
Lesson 5: Technical drawing of specifications and manufacturing steps . 23
Lesson 6: Market analysis 24
Lesson 7: Planning an advertising campaign 25
Lesson 8: Creating a magazine ad 26
Lesson 9: Producing the product 27
Lesson 10: Final presentation
Unit evaluation 28
Unit resources 29
Attachment 1: rules for group work 30
Attachment 2 Complete assignment sign-off form 31
Attachment 3: Personal shield 32
Attachment 4: Survey questions for group activities 33
Attachment 5: Product description 34
Attachment 6: Company name and letterhead 35
Attachment 7: Sample flow chart 36
Attachment 8: Sample cost sheet 37
Attachment 9: Market analysis 38
Attachment 10: Advertising campaign 39
Attachment 11: Library assignment 40
Attachment 12: Group evaluation questionnaire 42

Figures

Figure 1: Create-A-Product Unit Objectives 5
Figure 2: Tech Prep Goals (Foundations) and Unit Objectives 6
Figure 3: Tech Prep Goals (Competencies) and Unit Objectives 9
Figure 4: Language Arts Proficiencies and Unit Objectives 12
Figure 5: Conceptual Framework for Create-A-Product 15
Figure 6: Unit Activities and Instructional Strategies 17

Module 2: Prototype Units in Mathematics

Introductory comments for teachers

Abstract. Discusses relationship of prototype units to NCTM Standards and pedagogical issues such as use of calculators and grouping students for cooperative learning.

Background 3
Using the sample mathematics units in the classroom 3
Are the units of value to preservice teachers 4
Where do the units fit into the Tech Prep curriculum 4
Should students be given copies of each lesson 4
Can I adapt the units to fit the needs of my students 4
How do students react to these materials 5
How should students be grouped to do the activities in the lessons 5
Should students be allowed to use calculators 5
Why are most examples in these units in metric 5
Do I need to work with teachers from other subject areas 5
How do I take different learning styles into account 6
How do I assess student learning of the concepts in these units 6
Can I use computers with these units 7
Where can I get additional applications based materials 7
Summary 7
References 7

Unit 1: Ratios

Abstract. Beginning with ratio of diameter to circumference of circles and continuing with gear ratios in a bicycle, and ending with Ohm's Law, this unit develops the concepts of ratio and proportional relationships.

Lesson 1: Radius, diameter, and circumference 3
Lesson 2: How far do wheels travel? 7
Lesson 3: Ratios 13
Lesson 4: Scale drawing 17
Lesson 5: Putting it all together 21
Lesson 6: Proportions 23
Lesson 7: Inverse proportions 27
Lesson 8: Ohm's Law 33

Unit 2: Systems of Equations

Abstract. Linear equations are used to describe the dimensions of pipes and washers, and a variety of procedures are presented for solving such equations.

Introduction 3
Lesson 1: Writing linear relations 4
Lesson 2: Linear equations 7
Lesson 3: Solving break-even problems with graphs 15
Lesson 4: Solving systems of equations graphically 19
Lesson 5: Solving systems of equations by substitution 24

Module 2 (cont.)

Unit 2: Systems of Equations (cont.)

Lesson 6: Solving systems of equations by simultaneous solution 33
Lesson 7: (Optional) Determining the break-even point of a small business 42

Module 3: Prototype Units in Science

Introductory comments for teachers

***Abstract**. Discusses equipment needs and other issues related to the use of the prototype units.*

Overview 3
Implementation 3
Notes about the units 3
Evaluation 3
Science unit preview 4
Equipment & software for units 4

Units 1, 2 and 3

Unit 1: Robotics 3

Abstract. A general science unit with high utilization of technology.

Unit 2: Wave motion and light 4

Abstract. A physical science unit with low, medium, and high utilization of technology.

Unit 3: Microscope investigations 6

Abstract. A life science skills unit with low, medium, and high utilization of technology.

Unit 4: Spectrophotometry

Abstract. A chemistry unit on instrumental methods of analysis. Can be taught at low, medium, or high levels of technology use.

Introduction 3
Sample lesson unit for Tech Prep chemistry 4
  Integration level 1: Independent chemistry teacher 4
  Integration level 2: With an electronics teacher 6
  Integration level 3: A team of teachers (math & English) 7
  Implementation level 1: Low cost technology 8
  Implementation level 2: Moderate technology 10
  Implementation level 3: Advanced technology 16
  Recommended level 4: Advanced technology 19
  Recommended applications: Applied technology 19
Course outline 20
Unit outline/schedule 21

Module 4: Prototype Units in Technology

Introductory Comments for Teachers

__Abstract__. Importance of competency based instruction and guidelines for developing competency based curricula for technology. Tech Prep instructional strategies are discussed in the context of technology.

Module 4 Table of Contents iii
The technology teacher in Tech Prep 1
Competency-based instruction (CBI) 2
    Why CBI 2
    Are your courses competency based 2
    Overview of competency based instruction 3
    How to write CBI units 6
    Scope statement worksheet 7
    Tips for teachers when writing "Duties" 8
    Tips for teachers when writing "Tasks" 9
Tech Prep Instructional Strategies 10
    Cooperative learning 10
    Learning styles 11
    Learning theories 11
    Decision making 12
    Problem solving 13
    Project activity 1: Environmental concerns 14
    Project activity 2: Video Yearbook 16
Overview of the Problem Solving Process 18
    Situation acceptance 19
    Analysis 19
    Brainstorming 19
    Morphological forced connections 19
Classroom Application of the Problem Solving Process 21
Evaluating students on the Problem Solving Process 22
Glossary 23
References 24

Unit 1: Experiences in Technology

__Abstract__. Examples of scope statement and one duty, including its associated tasks, is shown to provide examples of Phases 1, 2, and 3 of CBI curriculum development as described in the Introductory Comments for Teachers.

Scope statement 3
Phase 1 3
Phase 2: Task 1: Identify major internal components of an IBM computer . 4
Phase 2: Task 2: Use the format command 5
Phase 2: Task 3: Use the copy command 5
Phase 2: Task 4: Perform hard drive management operations 6
Phase 2: Task 5: Manipulate data input devices 7
Phase 2: Task 6: Use desk accessory applications 7
Phase 2: Task 7: Perform diskette management operations 8
Technology preparation proficiencies 9

Module 4 (cont.)

Unit 2: Integrated Material Handling

Abstract. This unit integrates activities in mathematics, science, and communications during the development of concepts on material handling.

Introduction 3
Suggested competencies 3
Integrated activities matrix 4
Material handling unit 5
Overview of conveyer belts 6
Overview of Just-in-Time 7
Design brief: Automated manufacturing material handling processes 8
Lesson plan: Day 1 9
Lesson plan: Day 2 9
Lesson plan: Day 3 10
Log sheet 11
Lesson plan: Day 4 12
Suggested table for time and motion study 12
Lesson plan: Day 5 13
Suggested table for time and motion study 13
Homework 14
Glossary 15
References 16

Unit 3: Environmental Design

Abstract. Students are taught to design and text a water purification unit suitable for home use.

Introduction 3
Tech Prep drafting/CAD and the design process 3
Overview of water purification 3
Table 1: Water Treatment System vs. Common Contaminants 5
Integration activities matrix 7
Possible topics for discussion 7
Design brief 9
Lesson plan: Day 1 9
Possible ideation topics 10
Lesson plan: Day 2 11
Lesson plan: Day 3 11
Lesson plan: Day 4 12
Lesson plan: Day 5 12
Lesson plan: Day 6 13
References 14

Module 5: An Interdisciplinary Module on Bar Coding

Abstract. This module provides background information about bar coding technology followed by abbreviated lesson plans presented in the form of "design briefs." There are design briefs dealing with technology, language arts, mathematics, and science. The unit illustrates instruction that involves several subjects integrated through a particular workplace application.

Background for Teachers

Introduction 3
Background on bar coding 4
  Automatic identification and automatic data collection 4
  Reasons for auto ID 5
Bar coding technology 5
  Reading bar codes 5
  Scanner types 5
Common bar code symbologies 6
  Codabar 7
  Code 128 8
  Interleaved 2 of 5 9
  Postnet 10
  Code 39 11
  Universal product code 12
Classroom applications of bar codes 14
Troubleshooting 16
Bar coding in the future 16
Glossary 17
Reference list of bar coding software and hardware vendors 19
Handouts and examples 21
  Graphic 1: Auto ID is Keyless Data Entry 22
  Graphic 2: There is No "Best" Auto ID Technology 23
  Graphic 3: How Bar Code Scanners Work 24
  Graphic 4: Discreet vs. Continuous Codes 25
  Graphic 5: Mag Stripe Overview 26
  Graphic 6: Radio Frequency Identification 27
  Graphic 7: Various Types of RFID 28
  Graphic 8: Keyboard Interface Driver "Wedge" 29
  New York Times Article: For Bar Codes, an Added Dimension . . . 30

Language Arts Design Briefs

Abstract. This unit presents sample projects, called Design Briefs, for language arts teachers who make use of the material presented in Background for Teachers. These projects were designed to be used in concert with projects in Mathematics Design Briefs, Science Design Briefs, and Technology Design Briefs.

The role of language arts in the interdisciplinary Tech Prep classroom . . . 3
Design Brief 1: Technical writing: Documentation for computer software . 4
Design Brief 2: Multimedia presentation 7
Design Brief 3: Sales presentation 10
Design Brief 4: Creative Writing 13

Module 5 (cont.)

Mathematics Design Briefs

Abstract. This unit presents sample projects, called Design Briefs, for mathematics teachers who make use of the material presented in Background for Teachers. These projects were designed to be used in concert with projects in Language Arts Design Briefs, Science Design Briefs, and Technology Design Briefs.

The role of mathematics in the interdisciplinary Tech Prep classroom 3
Design Brief 1: Cracking a bar code 5
Design Brief 2: Finding the missing check number 6
Design Brief 3: Cracking another bar code 7
Design Brief 4: Is the UPC-A scheme sufficient 8
Design Brief 5: Revising the UPC-A system 9
Design Brief 6: Coding errors: Which ones get through 10
Design Brief 7: Coding errors: Comparing two bar codes 11
Design Brief 8: Using binary numbers 12
Design Brief 9: Measurement and area 13
Other math bar code topics for consideration 14
Student Glossary 15
References 16

Science Design Briefs

Abstract. This unit presents sample projects, called Design Briefs, for science teachers who make use of the material presented in Background for Teachers. These projects were designed to be used in concert with projects in Language Arts Design Briefs, Mathematics Design Briefs, and Technology Design Briefs.

The role of science in the interdisciplinary Tech Prep classroom 3
Design Brief 1: Scanner analysis 4
Design Brief 2: Scanner research document 6
Design Brief 3: Spectroscopy 8
Design Brief 4: Holography 11

Technology Design Briefs

Abstract. This unit presents sample projects, called Design Briefs, for Technology teachers who make use of the material presented in Background for Teachers. These projects were designed to be used in concert with projects in Language Arts Design Briefs, Mathematics Design Briefs, and Science Design Briefs.

The role of technology in the interdisciplinary Tech Prep Classroom 3
Design Brief 1: I've been on the line 4
Table 1: UPC Encodation Scheme 5
Design Brief 2: Move that pallet, stack that box 6
Design Brief 3: Clock me in 8

DIVISION III

Division III Table of Contents iii

Overview: Staff Development Workshops

Abstract. Rationale for staff development materials in Division III. These materials are designed to be used in conjunction with material in Divisions I and II to prepare teachers and staff who will develop Tech Prep programs. Primarily of interest to those responsible for staff development.

Introduction 3
Why Tech Prep 3
The dilemma 3
The workshop approach 4
    Concept defined 4
    What is a concept structure 4
Workshop organization 5
Assumptions about participants 5
Intended outcome 6

Workshop 1: Curriculum Development

Abstract. The first of four staff development workshops, this workshop introduces the use of concept structures as a curriculum building tool. Primarily of interest to those responsible for staff development.

Overview 3
Trainer material 4
Trainee material 13
DACUM analysis sheets 16

Workshop 2: Identifying Tech Prep Content

Abstract. The second of four staff development workshops, this workshop uses concept structures to identify course content and level. Primarily of interest to those responsible for staff development.

Overview 3
Trainer material 4
Trainee material 9

Workshop 3: Developing Tech Prep Instructional Materials

Abstract. The third of four staff development workshops, this workshop uses concept structures to develop both group and individual instructional materials. Primarily of interest to those responsible for staff development.

Overview 3
Trainer material 4
Trainee material 11

APPENDICES

Appendix A: List of Contributors to the Indiana Tech Prep Training Manual
Appendix B: Curriculum Materials for Applied Academics
Appendix C: Catalog of materials available from the National Tech Prep Clearinghouse of Resources
Appendix D: Indiana Schools Using Applied Courses
Appendix E: Regional and National Reports Containing Lists of Competencies Important for Tech Prep
Appendix F: Articulation Agreement: IVTC-Northcentral and Mishawaka

TECHPREP
INDIANA

TRAINING MANUAL
DIVISION I

Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

Abstract

Materials in this division supplement information in Hull and Parnell (1991) and provide general background information about Tech Prep. Chapter 1 is of general interest; Chapters 2, 5, 6, 7 and 9 are primarily for Tech Prep coordinators and other leaders; and Chapters 3, 4 and 8 are intended for those who are responsible for developing Tech Prep curriculum.

August 1992

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

Division I Table of Contents

Division I Table of Contents iii

Chapter 1: Introduction to Tech Prep

Abstract. Brief overview of Tech Prep. Description of origins of Tech Prep at national and state level. Organization of Tech Prep in Indiana. Goals, including distinctive features of Indiana Model. Summary of legislation that affects Tech Prep. Recommended reading for anyone who is just learning about Tech Prep.

The National Tech Prep Movement 3
Tech Prep in Indiana 3
    Organization 5
    Goals of Tech Prep 5
The Indiana Tech Prep Model 7
Legislative Summary 7
P. L. 217-1987 9
P. L. 19-1992 12
Perkins Act 16
References 20

Figures

Figure 1: State Tech Prep Organization 4
Figure 2: Regional Tech Prep Organization 6
Figure 3: Tech Prep Curriculum Model for Indiana 8

Chapter 2: Providing Leadership for Tech Prep

Abstract. Reference is made to Hull & Parnell where practical leadership issues are addressed. Indiana's legislative mandate and rationale for it are discussed before addressing what leaders need to do to move forward with Tech Prep under conditions of limited resources. Tech Prep leaders will find arguments that can help them respond to concerns within their region.

Introduction 3
Legislative Mandate 3
Tech Prep has Merit 4
Moving forward with Tech Prep 6
Identifying and securing resources 6
References 9

Chapter 3: Curriculum Development for Tech Prep

Abstract. Explains three essential elements of Tech Prep curriculum: applied academics, integrated subjects, and competency based curriculum. Steps in developing the Tech Prep curriculum are explained along with levels of implementation that are unique to Tech Prep. Primarily of interest to those developing curriculum materials.

Introduction 3
Characteristics of the Tech Prep Curriculum 3
    Applied Academics 3
    Integrated Subjects 5
    Competency based Curriculum 6
Curriculum Development 8
    Review the needs of the community 8
    Review the current curricula 9
    Identify and do away with duplication 9
    Modify and develop courses as needed 9
Levels of implementation 9
    Hull and Parnell's Levels 10
    Levels of technology use 10
    Levels of collaboration 10
Table 1: Models of Integrating Vocational and Academic Education 12
Summary of models in Table 1 14
References 20

Chapter 4: Instructional Strategies for Tech Prep

Abstract. Describes instructional strategies that characterize Tech Prep. Among topics discussed are problem solving, cooperative learning, and learning styles. Of particular interest to individuals who will develop or teach Tech Prep courses.

Introduction 3
Applications based instruction 3
Learning Styles 8
Cooperative Learning 9
Problem Solving 11
References 14

Chapter 5: Articulation

Abstract. Suggestions for developing articulation agreements between secondary and postsecondary institutions.

Introduction 3
Principles of articulation 3
    Leadership and commitment 3
    Early faculty involvement 3
    Respect and Trust 4
    Mutual benefits to all parties 4
    Written articulation agreement 4
    Open, clear, and frequent communication 4
    Modest initial goals 5
    Accountability 5
    Competency based curricula 5
    A common focus on mutual goals rather than on individual turf 5
Process of articulation 5
    Advanced placement or credit 5
    Stages of articulation 6
References 7

Chapter 6: Smoothing the Rough Spots

Abstract. Discussion of issues that may impede implementation of Tech Prep. Suggests mechanisms for dealing with the issues. Of particular interest to regional and local leaders.

Introduction 3
Teacher concerns 3
Administrative concerns 3
2+2, 4+2, 2+2+2, 4+2+2 4
Student ability levels 4
Staff development 5
References 6

Chapter 7: Economics Education for Tech Prep

Abstract. Brief description of the Indiana Council for Economic Education and how they might assist with Tech Prep curriculum development. Of particular interest to individuals responsible for curriculum development.

Introduction 3
Background on Indiana Council for Economic Education 3
Need for economic education in Tech Prep 3
An economic education/workplace literacy program 3
Attachment 1: Indiana Council for Economic Education 5
Attachment 2: Choices and Changes Curriculum Summary 7

25

Chapter 8: Tech Prep as Systemic School Reform

Abstract. Discussion of other school reform with emphasis on how Tech Prep fits with these other reform efforts. Of primary interest to individuals in schools already involved in another school reform effort.

In the aftermath of A Nation at Risk 3
Indiana 2000 and Tech Prep 3
Re: Learning and Tech Prep 3
SREB and Tech Prep 5
Other school reform 5
ASCD and Tech Prep 5
References 6
Principles Guiding Futures Planning for Curriculum Renewal by Cawelti 7

Chapter 9: Evaluation of Tech Prep Programs

Abstract. The CIPP program evaluation model is outlined, key evaluation questions are mentioned, and evaluation methods are described. Primarily of interest to those who are responsible for program evaluation.

Program evaluation model 3
The CIPP model 3
    Context evaluation 3
    Input evaluation 4
    Process evaluation 4
    Product evaluation 4
Key evaluation questions 4
Evaluation methods 5
The evaluation design and plan 5
    A. Setting the stage 5
    B. Collecting information 6
        Initial and Post performance 6
        Program execution 6
        Costs 6
        Indirect impact and attitudes 7
References 7
Self-Rating scale 8

Chapter 1

INTRODUCTION TO TECH PREP

by
J. Dudley Herron
Professor of Science Education
Department of Curriculum and Instruction
Purdue University

Abstract

This chapter gives a brief overview of Tech Prep. It contains a succinct description of its origins at both the national and state level, figures showing the organization of Tech Prep in Indiana, the goals of Tech Prep including distinctive features of Tech Prep in Indiana, a description of the Indiana Tech Prep Model, and a summary of the legislation that affects Tech Prep. This chapter will be of interest to anyone who is just beginning to learn about Tech Prep.

Indiana Tech Prep Training Materials: Division I
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

INTRODUCTION TO TECH PREP

The National Tech Prep Movement

Our nation is confronted with the challenge of global economic competition. Because of the nature of advances made in technology and the impact of these changes in the workplace, secondary and postsecondary educational institutions are under pressure to increase the number of technically prepared graduates. Many students emerge from high school with a diploma in hand, neither ready to enter the work force nor ready to pursue some form of postsecondary education. This dilemma comes at a time when knowledge is increasing at an exponential rate, traditional employment and job skills are diminishing, and new jobs and occupations require new abilities and experiences. Tech Prep is an effort to address these problems.

The origins of Tech Prep can be traced to federal "manpower legislation" enacted in the 1960's. It was in response to that legislation that Dale Parnell, then Superintendent of Public Instruction, Oregon State Board of Education, headed The Community College/High School Articulation Task Force II in 1968. This task force initiated several ideas for the improvement of vocational/technical education. Over the years these ideas were elaborated and refined, and in 1985 Parnell published The Neglected Majority which provided the blueprint for today's Tech Prep programs.

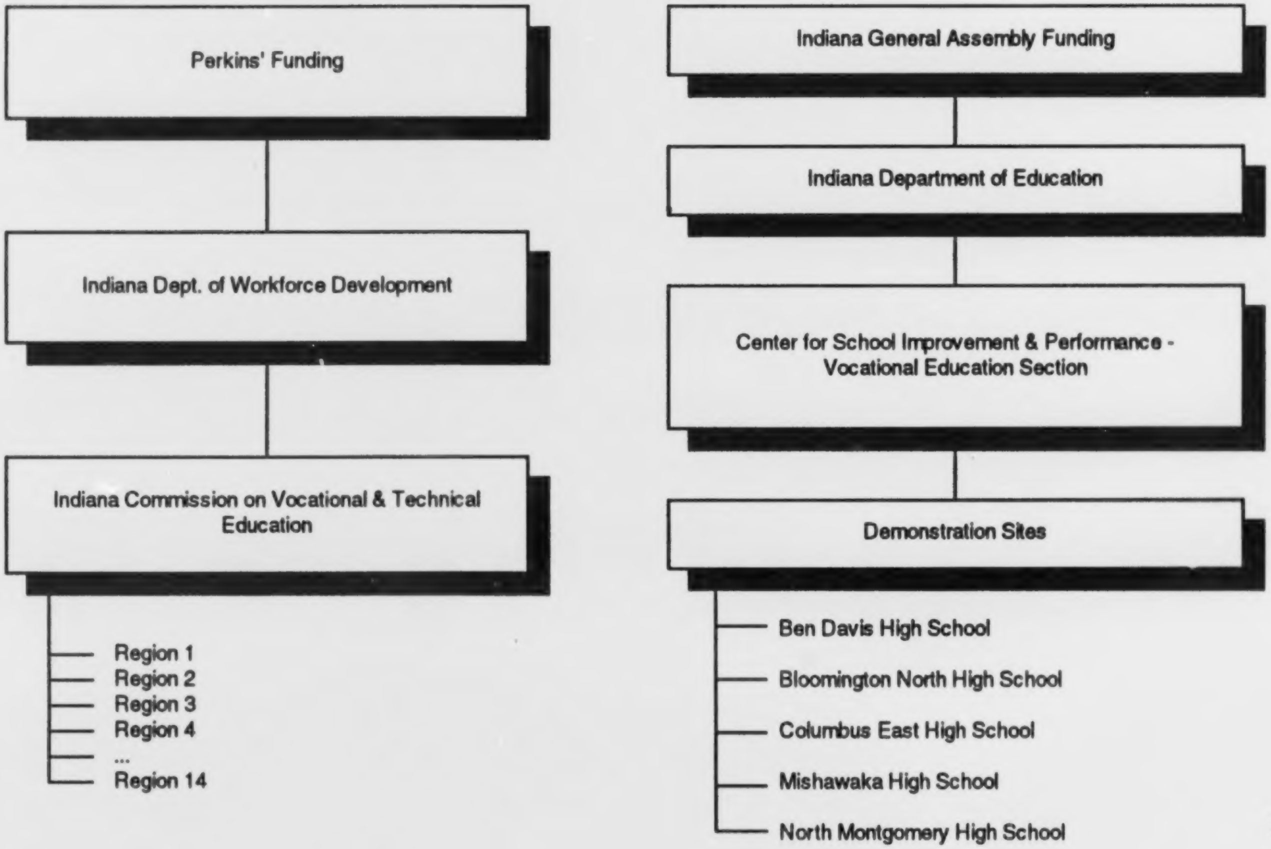
If you have not read The Neglected Majority, you should read Chapter 1: Every Student a Winner in Hull and Parnell (1991). In that chapter Parnell presents the case for Tech Prep/Associate Degree programs (TPAD). It is the argument that convinced the 1987 Indiana General Assembly to mandate Tech Prep programs for all secondary students in the state.

Tech Prep in Indiana

Indiana Tech Prep had its origins in the 1987 General Assembly. P.L. 217-1987 called for the establishment of a technology preparation task force to design and approve technology preparation curriculum models and teacher and staff training to implement the technology preparation models. The legislation also stipulated that the curriculum models must a) be performance based; b) provide students with the skills necessary to gain employment or pursue further education upon graduation; c) relate to a broad scope of occupational opportunities; d) include math, science, and English/language arts courses taught through practical application and designed to meet graduation requirements in those subjects; e) be designed to include secondary and postsecondary sequence models; and f) allow for dual credit, advanced study, and cooperative agreements.

Subsequent to passage of P.L. 217, a task force was appointed to formulate a model for Tech Prep, and five school corporations [Bartholomew Consolidated School Corporation in Columbus; Ben Davis High School in Wayne Township, Indianapolis; Monroe County Community School Corporation in Bloomington; School City of Mishawaka in Mishawaka; and North Montgomery High School near Crawfordsville] were funded in 1988-89 and 1989-90 through the Indiana Department of Education (IDOE) to assist in designing and implementing the model. In the 1991-92 school year these five school corporations were designated as Demonstration Sites and were funded to assist others in developing and implementing Tech

Figure 1. State Tech Prep Organization



Perkins' Funding

Indiana Dept. of Workforce Development

Indiana Commission on Vocational & Technical Education

- Region 1
- Region 2
- Region 3
- Region 4
- ...
- Region 14

Indiana General Assembly Funding

Indiana Department of Education

Center for School Improvement & Performance - Vocational Education Section

Demonstration Sites

- Ben Davis High School
- Bloomington North High School
- Columbus East High School
- Mishawaka High School
- North Montgomery High School

Prep programs. At the same time, fourteen regional consortia of secondary and postsecondary schools were funded through the Indiana Department of Workforce Development to develop and implement Tech Prep programs.

Organization. Figure 1 shows the organization of Tech Prep at the state level. As shown in the figure, the Demonstration Sites and Teacher/Staff Training are funded by state monies through IDOE; the Regional Consortia are funded by federal (Perkins) monies through the Department of Workforce Development.

Regional organization varies from one region to another, but Figure 2 showing the organization in Region 1 is representative. In each case several secondary school corporations in several counties and one or more postsecondary institutions are involved. Each region has some kind of advisory committee and a regional coordinator who is responsible for orchestrating Tech Prep activities within the region. Most regions also have committees charged with responsibilities such as promotion or marketing of Tech Prep, curriculum development, and evaluation.

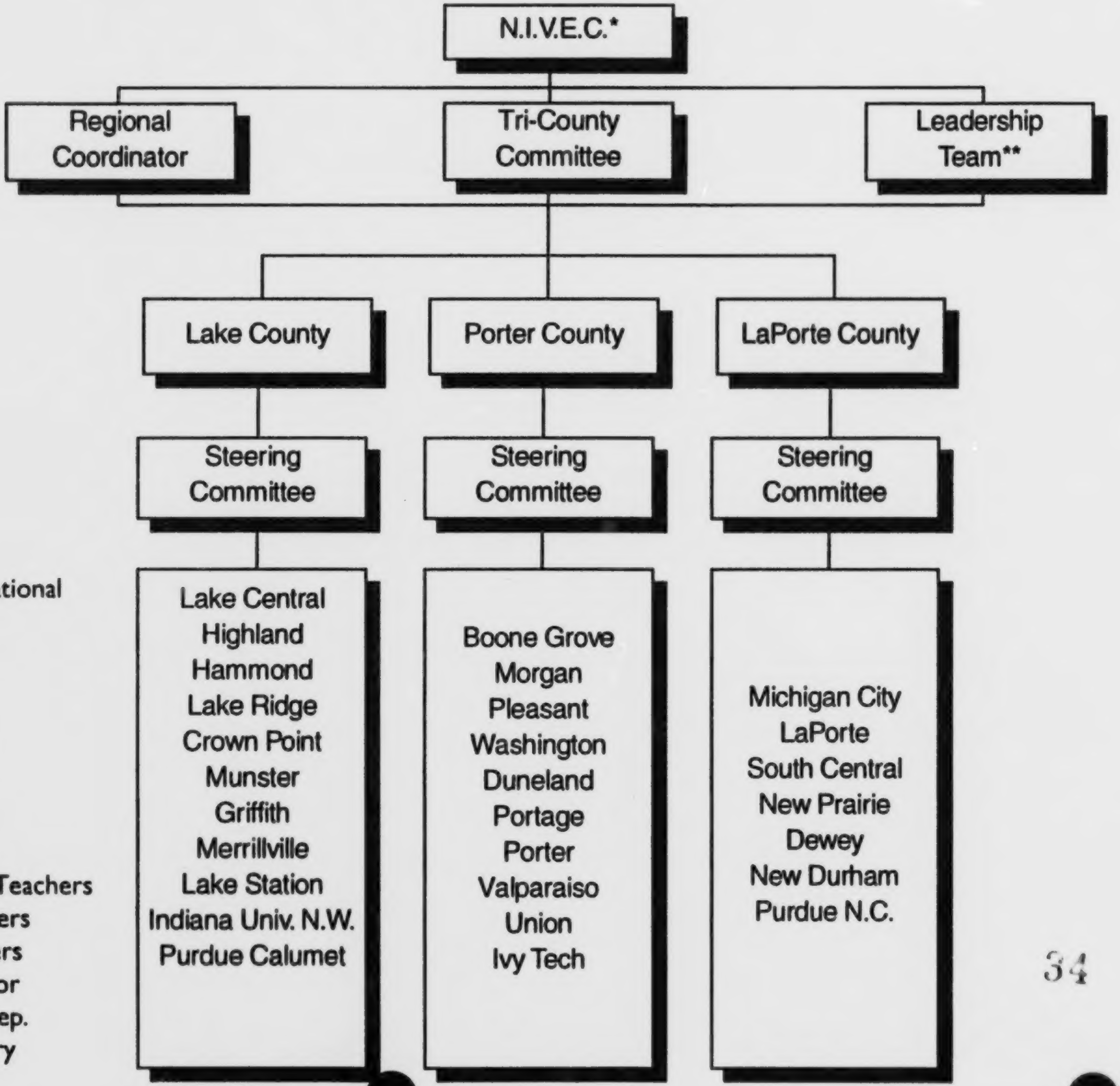
It is anticipated that as each school corporation within a region assumes ownership for Tech Prep it will select a coordinator for local implementation, establish committees paralleling those at the regional level, and form development teams composed of administrators; counselors; math, science, English, vocational-technical, and technology teachers; and community representatives to develop the local Tech Prep program.

Goals. The goals of Tech Prep in Indiana are essentially the same as national goals. However, the Indiana Tech Prep Model goes beyond TPAD as described by Hull and Parnell (1991). Hull indicates that "for a curriculum to qualify as TPAD . . . it should:

- run parallel to--not replace--college prep/baccalaureate degree programs,
- build an advanced-skills technical education on a common foundation of math, science, communications, and social sciences,
- lead to an associate degree or two-year certificate,
- incorporate relevant (real-life) applications of what is being taught--in other words, be built around applied academics,
- use a competency-based core curriculum structured around a career cluster of occupations, and
- provide employable skills at the conclusion of the high-school portion, so that, if circumstances require, students can work while completing their associate degree." (Hull & Parnell, p. 47)

Many schools in other states use existing courses to develop plans of study that will articulate with associate degree programs available in local community colleges, but little attention is given to the way courses are taught. Indiana's Model places a great deal of emphasis on teaching methodologies. It represents a significant school reform effort that can potentially impact the entire curriculum. In addition to the characteristics named by Hull and Parnell (1991), Indiana Tech Prep will:

Figure 2. Regional Tech Prep Organization



N.I.V.E.C.*

Regional Coordinator

Tri-County Committee

Leadership Team**

Lake County

Porter County

LaPorte County

Steering Committee

Steering Committee

Steering Committee

Lake Central
Highland
Hammond
Lake Ridge
Crown Point
Munster
Griffith
Merrillville
Lake Station
Indiana Univ. N.W.
Purdue Calumet

Boone Grove
Morgan
Pleasant
Washington
Duneland
Portage
Porter
Valparaiso
Union
Ivy Tech

Michigan City
LaPorte
South Central
New Prairie
Dewey
New Durham
Purdue N.C.

* Northern Indiana Vocational Education Council

** Consists of:
- Administrators
- Principals
- Counselors
- Math Teachers
- Science Teachers
- Communications Teachers
- Technology Teachers
- Vocational Teachers
- Vocational Director
- Post Secondary Rep.
- Business & Industry

- emphasize cooperative learning and/or other teaching strategies that stress teamwork and working effectively in groups,
- employ cooperative planning, team teaching, or similar procedures to effect subject matter integration across disciplines,
- acknowledge the variety of learning styles used by students and incorporate teaching strategies that will accommodate those styles, and
- require that each student develop an individual plan of study which reflects intended post high school goals and technical areas of interest.

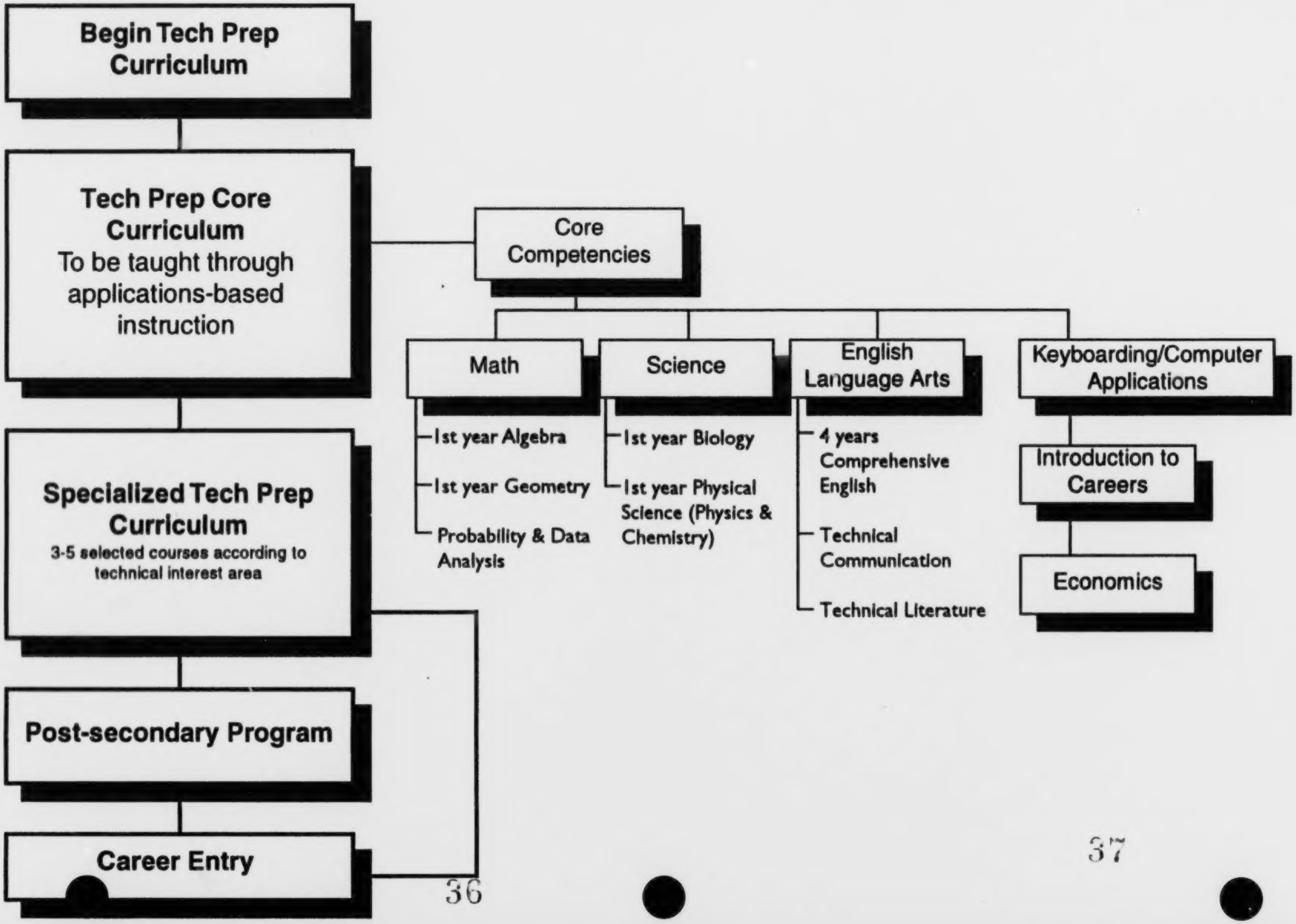
The Indiana Tech Prep Model. Tech Prep is a national reform effort with a variety of faces, but there exists in Indiana a specific model for that reform. At the heart of the Indiana Model (Figure 3) is a core program divided into two parts. The first part of the core consists of mathematics, science, and English/language arts. This part of the core is intended to receive major emphasis, and the competency levels in these areas are more clearly defined: In order to satisfy the mathematics core requirement, a student must be able to use algebra to solve problems, must be able to apply principles of geometry, and must understand fundamental concepts of probability and statistics. The student's science background must include understanding of science at a level comparable to that expected of students who have completed a traditional two-course sequence in biology and physical science (physics and chemistry), and the student's competence in English/language arts must match or exceed that acquired through the traditional four-course English sequence.

The second part of the Tech Prep core is less clearly defined. There are no benchmarks to indicate a minimum competency level. However, schools will need to show that Tech Prep students have acquired a basic understanding of economic principles, can demonstrate proficiency in keyboarding and computer applications, and are familiar with career opportunities.

The core portion of the Indiana Model is closely related to traditional academic courses, and it is conceivable that, in some schools, aspects of the core can be satisfied through existing course offerings. However, schools wishing to use existing courses as part of their Tech Prep Core must be prepared to pass a kind of litmus test implied by this appellation: "To be taught through an applications approach." The "applications approach" and the rationale for it is discussed in Chapter 3.

Legislative Summary. Three pieces of legislation, two state and one federal, help define Tech Prep. Indiana P.L. 217 (as amended), passed in 1987, established Indiana's Tech Prep program, and P.L. 19, passed in 1992, contains provisions that are likely to affect its implementation. In 1990 the 101st Congress amended the Carl Perkins Vocational and Applied Technology Education Act to include the Tech Prep Education Act. This act provided the funds under which the fourteen Indiana regional consortia are funded, and it will continue funding Tech Prep programs for four additional years. Descriptions of these acts follow with sections of particular interest to Tech Prep in bold face.

Figure 3. Tech Prep Curriculum Model For Indiana



Begin Tech Prep Curriculum

Tech Prep Core Curriculum
To be taught through applications-based instruction

Core Competencies

- Math
  - 1st year Algebra
  - 1st year Geometry
  - Probability & Data Analysis
- Science
  - 1st year Biology
  - 1st year Physical Science (Physics & Chemistry)
- English Language Arts
  - 4 years Comprehensive English
  - Technical Communication
  - Technical Literature
- Keyboarding/Computer Applications
  - Introduction to Careers
  - Economics

Specialized Tech Prep Curriculum
3-5 selected courses according to technical interest area

Post-secondary Program

Career Entry

Indiana Tech Prep Legislation

(P.L. 217-1987 as amended)

20-10.1-5.6-1 Establishment; members; curriculum models; secondary and postsecondary articulation curriculum agreements

Sec. 1.

(a) **The technology preparation task force is established to design and approve:**

(1) **technology preparation curriculum models; and**

(2) **teacher and staff training to implement the technology preparation models.**

(b) The state superintendent, the commissioner of the Indiana commission on vocational and technical education, and the executive officer of the commission for higher education shall appoint three (3) persons to the task force. The persons appointed to the task force must include representatives of local school corporations and state educational institutions.

(c) **The curriculum models developed by the task force must be developed by November 1, 1990, and must:**

(1) **be performance based;**

(2) **provide students with the skills necessary to gain employment or pursue further education upon graduation;**

(3) relate to a broad scope of occupational opportunities;

(4) **include math, science, and English/language arts courses, taught through practical application and designed to meet graduation requirements for those subjects;**

(5) **be designed to include secondary and postsecondary sequence models; and**

(6) **allow for dual credit, advanced study, and cooperative agreements.**

(d) **The task force shall identify certain occupations for secondary and postsecondary articulation curriculum agreements in cooperation with the standing technical committee of the Indiana commission on vocational and technical education.** ***As added by P.L.217-1987, SEC.11. Amended by P.L.51-1990, SEC.18.***

20-10.1-5.6-2 Technology preparation curriculum

Sec. 2.

(a) **By the 1990-91 school year, the department shall establish a schedule for school corporations to make fully available the technology preparation curriculum. By the 1991-92 school year, the state board of education shall establish a technology preparation curriculum to be phased in and made fully available to all high school students by the 1994-95 school year in accordance with the schedule and subsection (b).**

(b) **During the 1992-93 school year, the department shall designate one-third (1/3) of the school corporations to make available a technology preparation curriculum to high school students. During the 1993-94 school year, the department shall designate an additional one third (1/3) of the school corporations to make available a technology preparation curriculum to the school corporation's high school students. Beginning with the 1994-95 school year, the department shall require all school corporations to make available to the school corporation's high school students the technology preparation curriculum.**

(c) **The board shall implement teacher and staff training beginning with the 1990-91 school year.**

(d) This chapter does not eliminate the approved industrial arts/technology education curriculum adopted by the board by rule in effect on July 1, 1990. *As added by P.L.217-1987. SEC.11. Amended by P.L.342-1989(ss), SEC.16: P.L.51-1990, SEC.19.*

20-10.1-5.6-3 Equipment expenditures; funding

Sec 3. **Expenditure for equipment necessary to implement this chapter by a school corporation may be paid for:**

(1) through technology loans from the common school fund; or

(2) from the school corporations cumulative building fund under IC 21-2-6.

As added by P.L. 217-1987, SEC.11.

20-10.1-5.6-4 Rules

Sec. 4. The state board of education shall adopt rules under IC 4-22-2 to implement this chapter. *As added by P.L.217-1987, SEC.11.*

21-3-1.6-3.2 Additional count for participants in technology preparation programs

Sec. 3.2

(a) **The additional count for each pupil participating in technology preparation programs is set out below.** The additional count of the school corporation for this category is the aggregate additional counts of its pupils in this category with legal settlement in the school corporation.

(b) Participation does not require participation to the extent of full-time equivalency. **The state board of education shall adopt rules further defining the nature and extent of participation and the type of program qualifying for application of subsection (a). No additional count shall be made on any program set out in subsection (a) that has not been approved by the state board of education or where the student is not participating to the extent required by any rule of the board.**

(c) For the purposes of this chapter:

(1) **"additional count" of a school corporation or comparable language includes the aggregate of the additional counts of the school corporation for pupils as set out under subsection (a); and**

(2) references to section 3 of this chapter shall be considered to include this section.

As added by P.L.217-1987, SEC.21.

1992 PUBLIC LAW 19

(Note: Public Law 19 is 52 pages in length and covers many areas. Sections that have implications for Tech Prep are excerpted here.)

SECTION 10. IC 20-1-18.5 IS ADDED TO THE INDIANA CODE AS A NEW CHAPTER TO READ AS FOLLOWS:

Chapter 18.5. Work Force Partnership Plans

Sec. 1. As used in this chapter, "institution" means a campus of a state educational institution (as defined in IC 20-12-0.5-1), a school corporation, or an area vocational school as described in sections 2 and 3 of this chapter, whichever may apply.

Sec. 2. Subject to the guidelines developed under section 4 of this chapter, the chief administrator from each campus of a state educational institution that offers a technical education program (after receiving an endorsement from the faculty in this regard) must enter into a work force partnership plan as described under this chapter with the superintendent of the school corporation and each area vocational director who oversee the secondary level technical education programs that are offered within the same geographic area as the particular campus.

Sec. 3. Subject to the guidelines developed under section 4 of this chapter, the superintendent of each school corporation and area vocational director must enter into a work force partnership plan as described under this chapter with the chief administrator from each campus of a state educational institution (after the chief administrator receives an endorsement from the faculty in this regard) who oversees the postsecondary level technical education programs offered within the same geographic area as the school corporation and area vocational school.

Sec. 4.

(a) The:
  (1) superintendent of public instruction;
  (2) commissioner of the commission for higher education; and
  (3) commissioner of the Indiana commission on vocational and technical education; shall jointly develop guidelines governing the development of the work force partnership plans, including guidelines for the subjects described in subsection (b).

(b) The guidelines must cover the following:
  (1) A time schedule for institutions to comply with this chapter.
  (2) A format for the work force partnership plans.
  (3) Boundaries constituting the geographic areas described in sections 2 and 3 of this chapter.
  (4) Any other pertinent matter.

Sec. 5. Not withstanding any other law and after an institution is required to enter into a work force partnership plan under this chapter, to:
  (1) be eligible to receive federal and state funds for the institution's technical education program at the secondary level;
  (2) receive technical education program approval by:

        (A) the Indiana state board of education for secondary level programs; and
        (B) the commission for higher education for postsecondary level programs; for any technical education programs requiring approval; and
    (3) be eligible to complete the program review process by the commission for higher education for postsecondary level technical education programs; an institution's work force partnership plan must be approved by the Indiana commission on vocational and technical education.

Sec. 6. Each plan must do the following:

- (1) Address the need to maximize:
    - (A) the utilization of technical education programs and services; and
    - (B) the articulation of technical education programs; between the secondary level and postsecondary level.
- (2) Identify technical education program groupings to coordinate technical education programs within a geographic area.
- (3) Identify particular certificates of achievement under IC 20-10.1-4.4 and IC 20-12-1-10 and indicate the circumstances under which a state educational institution may elect to grant academic credit to a student who does the following:
    - (A) Acquires the particular certificate of achievement.
    - (B) Satisfies the standards for receipt of academic credit as determined by the state educational institution.
- (4) Provide for the utilization of joint secondary level and post-secondary level faculty committees to organize technical education program articulation.
- (5) Comply with 20 U.S.C. 2301 et seq.

Sec. 7. The Indiana state board of education and the commission for higher education may review and provide recommendations on each plan biennially.

SECTION 20. IC 20-10.1-4-12 IS ADDED TO THE INDIANA CODE AS A NEW SECTION TO READ AS FOLLOWS:

SEC. 12.

(a) To:

- (1) educate students on the importance of their future career choices;
- (2) prepare students for the realities inherent in the work environment; and
- (3) instill in students work values that will enable them to succeed in their respective careers; and beginning with the 1994-95 school year, each school within a school corporation shall include in the school's curriculum for all students in grades 1 through 12 instruction concerning employment matters and work values.

(b) Each school shall:

- (1) integrate within the curriculum instruction that is; or
- (2) conduct activities or special events periodically that are; designed to foster overall career awareness and career development as described in subsection (a).

(c) The department shall develop career awareness and career development models as described in subsection (d) to assist schools in complying with this section.

(d) The models shall be developed in accordance with the following:
  (1) For grades 1 through 5, career awareness models to introduce students to work values and basic employment concepts.
  (2) For grades 6 through 8, initial career information models that focus on career choices as they relate to student interst and skills.
  (3) For grades 9 through 10, career exploration models that offer students insight into future employment options.
  (4) For grades 11 through 12, career preparation models that provide job or further education counseling, including the following:
    (A) Initial job counseling, including the utilization of job service officers to provide school based assessment, information, and guidance on employment options and the rights of students as employees.
    (B) Work place orientation visits.
    (C) On-the-job experience exercises.

(e) The department, with assistance from the department of labor and the Indiana commission on vocational and technical education shall:
  (1) develop and make available teacher guides; and
  (2) conduct seminars or other teacher training activities; to assist teachers in providing the instruction described in this section.

(f) The department shall, with assistance from the Indiana commission on vocational and technical education design and implement innovative career preparation demonstration projects for students in at least grade 9.

SECTION 25. IC 20-10.1-4.5 IS ADDED TO THE INDIANA CODE AS A NEW CHAPTER TO READ AS FOLLOWS:

Chapter 4.5. Student Career Plan

Sec. 1. As used in this chapter, "student" refers to a student who is enrolled in a school corporation in at least grade 9.

Sec. 2. In consultation with the student's guidance counselor and parents and upon the receipt by the student of a gateway certificate under IC 20-20.1-4.3, **each student shall develop a career plan in which the student does the following:**
  (1) Indicates the subject and skill areas of interest to the student.
  (2) Designs a program of study under the technology preparation curriculum under IC 20-10.1-5.6 or the college preparation curriculum under IC 20-10.1-5.7 for grades 11 and 12 that meets the interests and aptitude of the student.
  (3) Ensures that upon satisfactory fulfillment of the plan the student:
    (A) is entitled to graduate; and
    (B) will have taken at least the minimum variety and number of courses necessary to gain admittance to a state educational institution (as defined in IC 20-12-0.5-1).

Sec. 3. Any decisions with regard to the requirements under this chapter for a student who is a handicapped child under IC 20-1-6 shall be made in accordance with the individualized education program for that student and federal law.

Sec. 4. A career plan may be modified after initial development. However, the modifications may not interfere with the assurances described in section 2(3) of this chapter.

Sec. 5. Nothing in this chapter may be construed to prevent a student who chooses a particular curriculum under IC 20-10.1-5.6 ot IC 20-10.1-5.7 from including within the student's career plan individual courses or programs that:
- (1) are not included within the student's chosen curriculum; and
- (2) the student is otherwise eligible to take.

SECTION 29. IC 20-10.1-5.6-1, AS AMENDED BY P.L.51-1990, SECTION 18, IS AMENDED TO READ AS FOLLOWS:

Sec. 1.

(a) The technology preparation task force is established to design and approve:
- (1) technology preparation curriculum models; and
- (2) teacher and staff training to implement the technology preparation models.

(b) The state superintendent, the commissioner of the Indiana commission on vocational and technical education, and the executive office of the commission for higher education shall each appoint three (3) persons to the task force. The persons appointed to the task force must include representatives of local school corporations and state educational institutions.

(c) The curriculum models developed by the task force must:
- (1) be performance based;
- (2) **upon the satisfactory fulfillment of the curriculum:**
  - (A) provide a **student** with the skills necessary to gain employment upon graduation **from high school; and**
  - (B) **provide a student with the subject or skills areas required by a state educational institution (as defined in IC 20-12-0.5-1) to gain admittance into the respective state educational institution;**
- (3) relate to a broad scope of occupational opportunities;
- (4) include math, science, and English/language arts courses, taught through practical application and designed to meet graduation requirements for those subjects;
- (5) be designed to include secondary and postsecondary sequence models; and
- (6) allow for dual credit, advanced study, and cooperative agreements.

(d) The task force shall idenfity certain occupations for secondary and postsecondary articulation curriculum agreements in cooperation with the Indiana commission on vocational and technical education.

(e) **By July 1, 1993, the state board shall adopt the technology preparation curriculum models.**

Perkins Act: Part E--Tech-Prep Education

SEC.341.SHORT TITLE. This part may be cited as the 'Tech-Prep Education Act.'

SEC.342.FINDINGS AND PURPOSE.

(a) **FINDINGS.**--The Congress finds that--

(1) rapid technological advances and global economic competition demand increased levels of skilled technical education preparation and readiness on the part of youths entering the workforce;

(2) effective strategies reaching beyond the boundaries of traditional schooling are necessary to provide early and sustained intervention by parents, teachers, and educational institutions in the lives of students;

(3) a combination of nontraditional school-to-work technical education programs, using state-of-the-art equipment and appropriate technologies, will reduce the dropout rate for high school students in the United States and will produce youths who are mature, responsible, and motivated to build good lives for themselves;

(4) the establishment of systematic technical education articulation agreements between secondary schools and postsecondary educational institutions is necessary for providing youths with skills in the liberal and practical arts and in basic academics, including literacy instruction in the English language, and with the intense technical preparation necessary for finding a position in a changing workplace;

(5) by the year 2000 an estimated 15,000,000 manufacturing jobs will require more advanced technical skills, and an equal number of service jobs will become obsolete;

(6) more than 50 percent of jobs that are developing will require skills greater than those provided by existing educational programs;

(7) dropout rates in urban schools are 50 percent or higher, and more than 50 percent of all Hispanic youth drop out of high school; and

(8) employers in the United States pay an estimated $210,000,000,000 annually for formal and informal training, remediation, and lost productivity as a result of untrained and unprepared youth joining, or attempting to join, the workforce of the United States.

(b) **PURPOSE.**--It is the purpose of this part--

(1) **to provide planning and demonstration grants to consortia of local educational agencies and postsecondary educational institutions, for the development and operation of 4-year programs designed to provide a tech-prep education program leading to a 2-year associate degree or a 2-year certificate; and**

(2) **to provide, in a systematic manner, strong, comprehensive links between secondary schools and postsecondary educational institutions.**

SEC.343. PROGRAM AUTHORIZED.

(a) **DISCRETIONARY AMOUNTS.**--In any fiscal year in which the amount made available under section 3(d)(1)(E) to carry out the provisions of this part is equal to or less than $50,000,000, the Secretary, in accordance with the provisions of this part which are not inconsistent with this paragraph, shall award grants for tech-prep education programs to consortia of--

(1) local educational agencies, intermediate educational agencies or area vocational education schools serving secondary school students, or secondary schools funded by the Bureau of Indian Affairs; and

(2a) nonprofit institutions of higher education which offer a 2-year associate degree program, a 2-year certificate program, and which are qualified as institutions of higher education pursuant to section 481(a) of the Higher Education Act of 1965, including institutions receiving assistance under the Tribally Controlled Community College Assistant Act of 1978, or a 2-year apprenticeship program that follows secondary instruction, if such nonprofit institutions of higher education are not subject to a default management plan required by the Secretary; or

(2b) proprietary institutions of higher education which offer a 2-year associate degree program and which are qualified as institutions of higher education pursuant to section 481(a) of the Higher Education Act of 1965 if such proprietary institutions of higher education are not subject to a default management plan required by the Secretary.

(b) **STATE GRANTS.--**

(1) In any fiscal year for which the amount made available under section 3(d)(1)(E) to carry out the provisions of this part exceeds $50,000,000, the Secretary shall allot such amount to the States in accordance with the provisions of section 101(a)(2).

(2) From amounts made available to each State under paragraph (1), the State board, in accordance with the provisions of this part which are not inconsistent with this paragraph, shall award grants on a competitive basis or on the basis of a formula determined by the State board, for tech-prep education programs to consortia described in subsection (a)(1).

SEC.344. TECH-PREP EDUCATION PROGRAMS.

(a) **GENERAL AUTHORITY.**--Each grant recipient shall use amounts provided under the grant to develop and operate a 4-year tech-prep education program.

(b) **CONTENTS OF PROGRAM.**--Any such program shall--

(1) be carried out under an articulation agreement between the participants in the consortium;

(2) consist of the 2 years of secondary school preceding graduation and 2 years of higher education, or an apprenticeship program of at least 2 years following secondary instruction, with a common core of required proficiency in mathematics, science, communications, and technologies designed to lead to an associate degree or certificate in a specific career field;

(3) include the development of tech-prep education program curricula appropriate to the needs of the consortium participants;

(4) include in-service training for teachers that--

        - (A) is designed to train teachers to effectively implement tech-prep education curricula;
        - (B) provides for joint training for teachers from all participants in the consortium; and
        - (C) may provide such training in weekend, evening, and summer sessions, institutes or workshops;
    - (5) include training programs for counselors designed to enable counselors to more effectively--
        - (A) recruit students for tech-prep education programs;
        - (B) ensure that such students successfully complete such programs; and
        - (C) ensure that such students are placed in appropriate employment;
    - (6) provide equal access to the full range of technical preparation programs to individuals who are members of special populations, including the development of tech-prep education program services appropriate to the needs of such individuals; and
    - (7) provide for preparatory services which assist all participants in such programs.
- (c) **ADDITIONAL AUTHORIZED ACTIVITIES.**--Each such program may--
    - (1) provide for the acquisition of tech-prep education program equipment; and
    - (2) as part of the program's planning activities, acquire technical assistance from State or local entities that have successfully designed, established and operated tech-prep programs.

SEC.345. APPLICATIONS.

- (a) **IN GENERAL.**--Each consortium that desires to receive a grant under this part shall submit an application to the Secretary or the State board, as appropriate, at such time and in such manner as the Secretary or the State board, as appropriate, shall prescribe.
- (b) **THREE-YEAR PLAN.**--Each application submitted under this section shall contain a 3-year plan for the development and implementation of activities under this part.
- (c) **APPROVAL.**--The Secretary or the State board, as appropriate, shall approve applications based on their potential to create an effective tech-prep education program as provided for in section 344.
- (d) **SPECIAL CONSIDERATION.**--The Secretary or the State board, as appropriate, shall give special consideration to applications which--
    - (1) provide for effective employment placement activities or transfer of students to 4-year baccalaureate degree programs;
    - (2) are developed in consultation with business, industry, and labor unions; and
    - (3) address effectively the issues of dropout prevention and re-entry and the needs of minority youths, youths of limited English proficiency, youths with handicap, and disadvantaged youths.
- (e) **EQUITABLE DISTRIBUTION OF ASSISTANCE.**--In making grants under this part, the Secretary shall ensure an equitable distribution of assistance among States and the Secretary or the State board, as appropriate, shall ensure an equitable distribution of assistance between urban and rural consortium participants.
- (f) **NOTICE.**--
    - (1) In the case of grants to be made by the Secretary, each consortium that submits an application under this section shall provide notice of such

submission and a copy of such application to the State educational agency and the State agency for higher education of the State in which the consortium is located.

(2) The Secretary shall notify the State educational agency, the State agency for higher education, and the State council on vocational education of any State each time a consortium located in such State is selected to receive a grant under this part.

SEC.346. REPORTS.

(a) **REPORT TO THE SECRETARY.**--In the case of grants made by the Secretary, each grant recipient shall, with respect to assistance received under this part, submit to the Secretary such reports as may be require by the Secretary to ensure that such grant recipient is complying with the requirements of this part.

(b) **REPORT TO THE CONGRESS.**--After grant recipients who receive grants in the first year in which grants are made under this part complete their eligibility under the program, the Secretary shall submit to the Congress a report evaluating the effectiveness of the program under this part.

SEC.347. DEFINITIONS. For purposes of this part:

(1) The term 'articulation agreement' means a commitment to a program designed to provide students with a nonduplicative sequence of progressive achievement leading to competencies in a tech-prep education program.

(2) The term 'community college'--
  (A) has the meaning provided in section 1201(a) of the Higher Education Act of 1965 for an institution which provides not less than a 2-year program which is acceptable for full credit toward a bachelor's degree; and
  (B) includes tribally controlled community colleges.

(3) The term 'tech-prep education program' means a combined secondary and postsecondary program which--
  (A) leads to an associate degree or 2-year certificate;
  (B) provides technical preparation in at least 1 field of engineering technology, applied science, mechanical, industrial, or practical art or trade, or agriculture, health, or business;
  (C) builds student competence in mathematics, science, and communications (including through applied academics) through a sequential course of study; and
  (D) leads to placement in employment.

(4) The terms 'institution of higher education' and 'higher education' include institutions offering apprenticeship programs of at least 2 years beyond the completion of secondary school.

References

Hull, D. & Parnell, D. (1991). Tech Prep associate degree: A win/win experience. Waco, TX: Center for Occupational Research and Development.

Parnell, D. (1985) The neglected majority. Washington, D.C.: Community College Press.

CHAPTER 2

PROVIDING LEADERSHIP FOR TECH PREP

by

J. Dudley Herron
Professor of Science Education
Department of Curriculum and Instruction
Purdue University

Abstract

Reference is made to Chapters 2 & 4 in Hull and Parnell where practical concerns related to Tech Prep leadership are addressed. Indiana's legislative mandate and the rationale for it are discussed before addressing what leaders need to do to move forward with Tech Prep. Particular attention is given to the issue of limited resources. Tech Prep leaders will find arguments that can help them respond to concerns expressed within their region.

Indiana Tech Prep Training Manual: Division I
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

PROVIDING LEADERSHIP FOR TECH PREP

Introduction

All school reform requires leadership. A reform effort as complex as Tech Prep requires leadership from several ranks. School administrators, counselors, and teachers from several disciplines must be involved. Parents, representatives from business and industry, and administrators and faculty from postsecondary institutions must also be involved. An effective Tech Prep Consortium must include all of these groups.

Chapter 2 in Hull and Parnell (1991) explains why applied academics is needed as a foundation for technical careers. It also discusses the rethinking that is occurring concerning the structure of vocational education, especially the need for students to continue their education beyond secondary school. It goes on to provide a description of the various committees that will be needed to set up a Tech Prep consortium and the issues that consortium leaders must address. Chapter 4 provides more detailed information about planning and administering a TPAD program, committees and their duties, and mechanisms for staff development. The chapters are well done, and leaders will find many useful suggestions for getting a Tech Prep consortium off the ground.

The legislative mandate for Tech Prep in Indiana coupled with limited resources for implementation have resulted in some concerns that go beyond the practical problems addressed in Hull and Parnell (1991). Several of those issues are addressed in the following sections.

Legislative Mandate

Tech Prep is mandated in Indiana by P.L. 217-1987. Because of that mandate, every school corporation is obligated to develop and implement Tech Prep. Some will do so reluctantly; others will welcome the legislative impetus for moving schools in a sensible direction.

Nobody likes mandates, and it seems educators are always being forced to do one thing or another. They get tired of it. So tired that they have developed effective strategies for pretending to make change while going about business as usual. They change a few titles on paper, rearrange a schedule or two, publish a new syllabus, and declare that there is a new program. The changes are often cosmetic, and serious observers--students, for example--know that nothing has really changed. This can happen with Tech Prep. It shouldn't.

Castigating "the politicians down in Indy" is such a popular pastime that we need to remind ourselves that legislators are our neighbors. They live in Indiana. They care about the state, its people, and its schools. Superficial evidence to the contrary, they do not mandate programs just to be difficult. They do so in an effort to improve the state. Sometimes they are aware of problems that are vaguely understood by others. When they mandate a program that affects our lives, they deserve the courtesy of our attention long enough to decide whether the program has merit.

Tech Prep Has Merit

It is not necessary to recount the substantial changes in business and industry that have been brought about by advances in technology and international competition over the past decade or so. Anyone needing such a review hasn't been paying attention. We have a problem. We need to solve it. We need to solve it now.

Still, believing there is a problem is only half of the motivation needed to implement Tech Prep. One must also believe that Tech Prep can address the problem. To judge that, one must focus on the scope and nature of the problem.

Lauren Resnick gets to the crux of the problem in her 1987 book, Education and Learning to Think. Resnick points out that education has an elitist tradition. Whether acknowledged or not, schools have operated on the assumption that some people are born bright and some are born stupid; only the bright ones think. Historically, schooling was provided for the more affluent citizens. When education was extended to others, not all responded well to the curriculum designed for aristocrats, and over time general education and vocational education components were added to the curriculum. Only the top 20% or so--those in the so-called college prep curriculum--were in courses that covered the concepts of mathematics, science, and communication that provide the keys to understanding technologies that shape our modern world. These courses have traditionally stressed the development of independent thought, analytical skill, and metacognitive strategies used to solve novel problems.

The message from today's workplace is that everybody needs to think: the CEO, the worker on the factory floor, the office staff, and the sales force. There are good opportunities for those who think--for those who have the intellectual competencies traditionally associated with a college prep curriculum. That presents a dilemma: About 80% of students have never responded well to the academic curriculum, and we don't know whether it is possible to develop a curriculum that will produce in all students the same kind of intellectual competencies that traditionally have been developed in the top 20%. Finding out is the journey of Tech Prep.

The ultimate success of Tech Prep remains to be seen. However, the philosophy behind Tech Prep is sound, and programs at the pilot sites show promise. Teachers and students are working together and learning from one another. Students are on task, interested in what they are doing, and trying to solve problems. The curriculum makes sense, and the students know it.

There is general agreement among Indiana educators that Tech Prep is on target.

1. Tech Prep has the right target population, those students in the general education program who are being prepared for neither further education nor the world of work.

2. Tech Prep recognizes that general education students are often unfocused--just taking courses and biding their time before graduating or dropping out. It includes career education and counseling components that help students develop the focus that they need.

3. Tech Prep is a rigorous program. Students can't pass the courses until they demonstrate competence.

4. Although there is a carefully developed Tech Prep model in Indiana, the implementation of that model acknowledges that communities and schools are not the same throughout the state. There is flexibility in how the model may be implemented. Local administrators, teachers, and community leaders develop their own Tech Prep program. They are expected to make the program their own, to nurture it, and to monitor it continuously to ensure that it *continues* to meet local needs.

5. Tech Prep recognizes that most teachers went to college after high school. They have never had jobs in business or industry, and they aren't very familiar with the nature of work in those places. Consequently, people who do work in those places are involved in identifying the competencies that students need, and they remain involved to see that students gain them.

6. Tech Prep recognizes that most of the better jobs available today require more than a high school education. Many require the technical background available through associate degree programs, and Tech Prep aims at developing carefully articulated programs that allow students to begin a program of study in the high school and continue that program in another institution. In some cases the additional education can come in the workplace, and some Tech Prep students will be employed directly out of high school. But even then students must know how to learn, and Tech Prep emphasizes interpersonal skills, cooperative learning, problem solving, critical thinking, and strong communications skills that are necessary to learn on the job.

7. Tech Prep recognizes the influence of technologies based on math and science concepts. Core competencies (not necessarily courses) in math, science, English/language arts, economics, computer literacy, and career awareness are emphasized in the curriculum.

8. Tech Prep acknowledges that students learn in different ways, and many students in the target population do not respond well to formal lecture and abstract presentations. Concepts and principles are taught through practical application where students can see concrete examples, manipulate objects, and complete projects.

9. Tech Prep also acknowledges that the real world is not divided into convenient compartments that match the divisions of the traditional curriculum. The real world is divided into problems and tasks that require the integration of ideas and the simultaneous application of skills from many subject areas. Consequently, it encourages team teaching and joint instructional planning so that the curriculum better reflects reality.

10. Because the real world is made up of complicated problems and work tasks requiring contributions from many people, Tech Prep emphasizes problem solving, critical thinking, teamwork, and cooperative learning skills.

11. Above all, Tech Prep addresses the fact that many of the most important lessons taught in schools are a result of the *way* things are taught rather than *what* is taught. *The major distinction between Tech Prep and current academic course work is in the pedagogy rather than the content addressed.*

The concept of Tech Prep is a little like the concept of heaven; people like to believe heaven exists, but nobody is sure what it looks like. There are five groups throughout Indiana that have been moving toward Tech Prep, but nobody at those sites or in the Indiana Department of Education claims they have reached the Promised Land. They feel good about the road they are on, but none feel they've arrived.

The course set by the Indiana Tech Prep Model is not an easy one, and the state will not get far, regardless of the legislative mandate, if citizens and educators do not believe there is something seriously wrong with schools as they are and that Tech Prep can make schools better. In short, educational leaders must believe--and those they enlist in this effort must believe--that Tech Prep has merit.

Moving Forward With Tech Prep

Chapter 2 of Hull and Parnell (1991) is called "Getting Off the Ground." Indiana is beyond that point. Five pilot sites have operated for three years, and fourteen regional consortia have been formed to assist in implementing Tech Prep. The Department of Workforce Development has hired a coordinator for the program, and federal funds are being funneled through that department to the fourteen regional consortia to assist in planning, staff development, and marketing the program. The materials you are now reading have been prepared to assist you as well. Indiana *is* off the ground. Now we need to get down the road.

The fourteen regional consortia can assist in developing and implementing Tech Prep within their regions. The regional coordinators have books, curriculum materials, and other resources that local schools can use. In some areas--for example, in making contacts with business and industry and in identifying important competencies for Tech Prep--the regional consortia are beginning the development and implementation process for all schools within the region. However, they cannot do it all. In the final analysis Tech Prep must be implemented at the local level. Early in the process each school will need to institute at the local level the committees described in Chapters 2 and 4 of Hull and Parnell (1991) and begin making the decisions about what the local Tech Prep program must be.

Identifying and Securing Resources

Cost has been a major concern about the Indiana Tech Prep effort. The five pilot sites (now Demonstration Sites) received substantial state funding to begin their programs. That funding enabled Demonstration Sites to pay teachers to write curriculum materials during the summer, and it provided funds for computers and other equipment that is being used in Tech Prep courses. That equipment is quite visible, and visitors to the Demonstration Sites wonder aloud, "How does the state expect us to do *this* without money?"

There are real costs associated with any school reform, and Tech Prep is no exception. However, in the current economic climate it is unrealistic to assume that the Indiana General

Assembly will be able to fund Tech Prep at the level provided during the pilot stage. According to Clifton Belcher, State Director of Vocational-Technical Education in North Carolina, that level of support isn't needed. Speaking from his experience in North Carolina where Richmond County, one of the most celebrated Tech Prep programs in the U.S., is located, Belcher states:

> [I]f a system plans appropriately, major outside funding is not needed. (This assumes, of course that the system has *some* resources and is not starting from zero!) . . . One advantage of implementing TPAD as far as possible with existing resources is that such a program becomes institutionalized immediately. Using large outside sums for a project puts that program in danger of withering when the external funds dry up. This does not mean that additional resources are not needed, but they should be for one-time expenses such as planning and equipment rather than ongoing operational expenses. (Hull & Parnell, 1991, p. 145)

Belcher continues with specific suggestions for redirecting resources in order to implement Tech Prep programs, and you will find his suggestions in Chapter 5 of Hull and Parnell (1991) very helpful.

There is funding for Tech Prep in Indiana. The regional consortia are funded at least through June, 1994. The level of funding is modest, but it can provide much of the external assistance alluded to by Belcher. Schools should certainly take advantage of all training opportunities provided through the regional consortia, and they should use the materials in Division III of this manual to conduct workshops at the local level.

The major equipment need for schools is computers. That is the case whether the school is implementing Tech Prep or not. Computers are ubiquitous in our society, and schools are woefully behind in obtaining the kind and number that they need. There are at least three potential sources of funds within the normal school finance structure that can be used to buy computers and other equipment for Tech Prep.

Schools have the option to tax property at a rate up to $1.25 for the Capital Projects Fund. This fund is used for new construction or renovation of existing buildings. However, it can also be used for capital equipment such as computers. "Rich" districts with property to tax may find this to be a viable source of funding for Tech Prep equipment needs. "Poor" districts with little property will not. In all likelihood they are already taxing all that they can just to maintain buildings.[1]

Poorer districts do have first shot at the Common School Fund, a state fund that loans money for capital projects at a low rate of interest. The money in that fund is small enough that it is of little help when building a new building, but it can provide money for computers.

---

[1] The author has observed schools in Southeast Asia, Israel, Scotland, Germany, and several states in the US. Taken as a whole, school buildings in Indiana are among the best seen anywhere. The quality of instruction is not. We must ask ourselves whether reallocation of resources could lead to school improvement.

In a similar vein, it may be possible to negotiate a municipal lease to purchase equipment and then pay back the lease out of the Capital Projects Fund. Since this money must eventually be paid back, it is not the most attractive source of funding, but it can enable schools that are strongly committed to school reform to begin the process before they have local funds to address all of their needs.

In the event that bonds are sold for new construction, money for capital equipment can be included. Since this represents a special circumstance, it is of limited utility.

More viable sources of funds are those available through special grants. Most of these are one-time programs, making it impossible to give a more explicit suggestion than "be on the lookout for grant announcements that provide funding for purchase of computer equipment, teacher training, or other activities that could enhance Tech Prep."

Particular attention should be given to Eisenhower Grants. These are federal "pass through" funds for the improvement of science and mathematics. Part of the funds are administered through the Center for School Improvement and Performance at IDOE and are available only to elementary and secondary schools. Other Eisenhower Grants are administered through the Commission for Higher Education and may be awarded to colleges and universities, but their purpose is still to enhance science and mathematics education in elementary and secondary schools. Projects aimed at the science and math components of Tech Prep are certainly within the scope of this program.

All school corporations receive Chapter 2 funds. In most cases these monies could be used to purchase computers needed for Tech Prep. As with many other sources, diverting funds to this purpose will mean that the money is not available for other worthy projects, and each school corporation must set its priorities carefully.

Some schools have successfully solicited help from business and industry, have initiated campaigns like those often used to raise money for band uniforms, or have followed other entrepreneurial instincts to raise money for needed equipment. Project Activity 2 in the Technology Module in Division II is an excellent example of such entrepreneurial activity. Project Activity 2 calls for Tech Prep students to design a product, manufacture it, and sell it at a profit.

The message in this section is not that additional funding for Tech Prep isn't needed. Rather, the message is that Tech Prep can move forward while the economic situation improves and additional funding is provided so that Tech Prep realizes its full potential.

References

The following reference discusses conditions needed for effective school reform.

Fullan, M. & Miles, M. (1992). Getting reform right: What works and what doesn't. Phi Delta Kappan, 73, 745-752.

Hull, D. (1991). Getting off the ground: The basics of developing a TPAD consortium. In D. Hull & D. Parnell. Tech Prep associate degree: A win/win experience. Waco, TX: The Center for Occupational Research and Development.

Resnick, L. (1987). Education and Learning to Think. Washington, D.C.: National Academy Press.

CHAPTER 3

CURRICULUM DEVELOPMENT FOR TECH PREP

by

James E. Green
Professor of Secondary, Higher and Foundations of Education
Ball State University

and

J. Dudley Herron
Professor of Science Education
Department of Curriculum and Instruction
Purdue University

Abstract

This chapter explains three essential elements of the Tech Prep curriculum: applied academics, integrated subjects, and performance based instruction. Steps in developing the Tech Prep curriculum are explained along with levels of implementation that are unique to Tech Prep.

Indiana Tech Prep Training Manual: Division I
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

CURRICULUM DEVELOPMENT FOR TECH PREP

Introduction

Chapter 1 stated that the origins of Tech Prep can be traced to "manpower legislation" enacted in the 1960's. Others argue that Tech Prep sprang from the reform movement of the 1980's, with the urgent demands of global competition and technological progress. Still others argue that it is the maturation of the progressive education movement of the 1920's and 1930's that was inspired by John Dewey's vision of a new social order. Regardless of how Tech Prep began, one thing is certain: *Tech Prep represents change* from curriculum *status quo*. In this chapter the characteristics of curriculum which represent that change are explained, and the process of curriculum development for Tech Prep is discussed.

Characteristics of the Tech Prep Curriculum

It is in the areas of curriculum and pedagogy that Indiana Tech Prep differs most from Tech Prep in other states. The Indiana Tech Prep Model incorporates a combination of characteristics that have been known to knowledgeable teachers for more than half a century. Emphasizing applications, integrating subjects, learning in groups, addressing needs of individual pupils, and focusing on learning outcomes are not novel ideas. But, in the Indiana Tech Prep curriculum these characteristics are not embellishments. In Tech Prep they become the *sine qua non*. These concepts are discussed in Chapter 4, "Instructional Strategies for Tech Prep," because ultimately any curriculum will be known by how teachers teach. But three in particular--*applied academics*, *integrated subjects*, and *performance based instruction*--are fundamental to the initial design.

Applied Academics. Tech Prep emphasizes the integration of academic and technical subjects in a manner that has come to be know as *applied academics*. A rationale for applied academics and detailed examples are included in Chapter 3 of Hull and Parnell (1991). Some additional explanation will help teachers who are developing Tech Prep curricula.

The Southern Regional Education Board (SREB) State Vocational Education Consortium defined applied academics in a manner that is applicable to Tech Prep. The SREB's definition, which follows, should prove most useful to Indiana's Tech Prep teachers:

> Applied learning combines the essential elements of the college preparatory curriculum with effective learning and problem solving strategies in a broad technical or business field. The academic subject matter includes the essential concepts, facts, and procedures normally identified with college preparatory language arts, mathematics, and science courses. Students become familiar with the knowledge, technology, and skills in a business or technical field and with ways to use academic knowledge to perform tasks and solve problems within the field. (SREB, 1992, p. 39)

Applied academics is central to understanding Tech Prep curriculum for two reasons. First, emphasizing applications in the academic subjects that make up the core of Tech Prep ensures that students will understand the importance of what they are learning in a wide variety of occupations and to provide insight into what people in those occupations do.

Second, there is considerable evidence that students who have difficulty comprehending mathematics and science when presented in a formal, abstract manner are able to comprehend when those concepts and principles evolve from specific applications and concrete experiences.[1] For example, when Euclidian geometry is presented as a system of formal proofs which follow from a minimal set of axioms and postulates, most students have difficulty. But when projective geometry is presented through construction and examination of relationships among elements of the construction, students are able to understand. A Tech Prep curriculum should be designed so that *more students will be successful*. As effective teachers know, many students who are not facile with reasoning at the level of formal operations can learn conceptual subject matter if the concepts result from the students' concrete experiences.

For many teachers, especially ones in traditional vocational and technical programs, the call for applications based instruction in Tech Prep is a call for instruction based on *workplace applications*. Other teachers, especially those in the subject areas that make up the academic core, are afraid that an emphasis on workplace applications will dilute the Tech Prep curriculum and make it little more than job training. This tension is understandable, and resolving the issue requires a better understanding of the term "applied academics." An example from one of the units in Division II of this manual will help explain.

An early draft of the math materials was criticized by some teachers because the example of applications based instruction was developed around the concept of gear ratios on a bicycle. These educators criticized the lesson because there is little chance that a student will encounter this specific application in the workplace. Their reasoning implied that any example of applications based instruction should have a specific workplace application. This expectation misses the point of *applied academics* in Tech Prep. Nobody, including employers, wants to see secondary education narrowly focused on job training. But everybody, including the most ardent humanist, wants students to be prepared for gainful work. For some students that work will be in a studio producing works of art, for others it will be in an orchestra or on stage. Still others will work in professions for which several years of postsecondary education are required, and some will find jobs for which traditional vocational training is required. But a growing number will find employment in a wide variety of technical careers ranging from medical and social services to manufacturing and biotechnology to agribusiness, entrepreneurship, and business management. Diverse as these fields are, they will all utilize the competencies required in the Indiana Tech Prep core of academic subjects. (See Figure 3 in Chapter 1). Educational programs that do not develop these academic competencies deny students access to potentially rewarding careers.

The key issue is not whether gear ratios on a bicycle represent an application that students are likely to encounter later on in their place of work. That simply doesn't matter. What does matter is whether students will be able to apply the mathematical concept of ratio to whatever application they do encounter--be it drug dilutions in medicine, profit margins in business, or scale in technical drawing. If a specific application that is uncommon in the workplace accomplishes this, then it is a good application. If a workplace application fails to achieve that end, it is a poor application. It is likely that, in practice, no particular application will be effective for all students.

---

[1] This discussion is purposely brief and assumes that readers will be familiar with recent research in cognitive science. Representative publications supporting the claim are Gardner, 1991; Hiebert & Carpenter, 1992; Kloosterman & Gainey, in press; Resnick, 1987; Tobias, 1990.

Examples of applied academics. Division II contains instructional units that illustrate applied academics in Tech Prep, and many more examples are available from other sources. Examples of applied academics courses developed by CORD and AIT are described in Chapter 3 and Appendix B of Hull and Parnell (1991). A complete set of these materials can be obtained for review through the Indiana Literacy/Technical Resource Center.[2] Appendix D contains a list of the schools where one or more of these courses are in place. This list was compiled in June, 1992, and a current listing will be available from the Indiana Department of Education.

In addition, Appendix B contains examples that are from The Cunning Hand, the Cultured Mind: Models for Integrating Vocational and Academic Education (Grubb, 1991). It lists materials related to the integration of vocational and academic courses.

Another source of model courses in applied academics will be the Tech Prep demonstration sites in Indiana. Their materials are available on computer disks, and they can be obtained through Tech Prep regional coordinators. As with any curriculum, they are tailored to a specific school setting, and would require modification before they could be implemented in any other school.

Integrated Subjects. Implementing an applied academics curriculum requires new lines of thinking for the division of subject matter. Conventional disciplines soon become awkward to Tech Prep teachers who base their curriculum on applications. Just as problems that are solved in the workplace do not have distinct disciplinary lines, instructional units or even entire courses of study will naturally be without distinct disciplinary lines. This does not suggest that a Tech Prep curriculum should be a random collection of experiences; but rather, it simply acknowledges that ideas were generated and problems were solved long before knowledge was categorized by subject matter. And in the workplace of today and the twenty first century, we will continue to use ideas that do not know disciplinary boundaries, and we will be confronted with problems that will require complex solutions. Application of knowledge outside school does not designate a problem as a math problem or a science problem or a communications problem. It is always just a problem, and its solution usually demands knowledge from many fields.

The design and development of a Tech Prep curriculum should explicitly encourage integrated subject matter. An interdisciplinary curriculum can be accomplished through several strategies:

---

[2] Literacy/Technical Resource Center, 104 N. Senate, Room 208, Indianapolis, IN 46204 Phone: 1-800-233-4572 or (317) 233-5202

Teachers of two or more subjects can coordinate their instruction so that the same application is the focus in the different courses. With this strategy students have the opportunity to see that any problem usually requires different perspectives and understanding of broad concepts.

Often a Tech Prep teacher in a specific subject will teach a unit that must draw from other disciplines. In this case, the teacher needs to plan the unit with the assistance of another subject matter specialist. Teaching the unit usually entails the extensive participation of "experts" as supplementary sources of instruction and consultation during the unit. This model is not unlike businesses that use consultants when they are engaged in a project that requires an expertise that is different from that of the regular staff. For example, if a science class were conducting an environmental impact study as a class project, the English teacher would join the class for a period of time to teach students how to write the final technical report. The science teacher would evaluate the report for its scientific accuracy; the English teacher would evaluate the report for its quality of composition. Lest English teachers end up getting the "short end" of these "trades," the school's curriculum design will need to include a plan for content specialists to contribute to the units prepared for implementation in the English classes. Opportunities for this type of collaboration are limited only by the imaginations of the teachers. Several of the sample units in Division II of this manual illustrate the integration of academic subjects.

The most ambitious strategy for producing an interdisciplinary curriculum for Tech Prep is designing courses that are organized around the applications, with the subject matter selected according to its relevancy (as opposed to inserting a relevant application into a course that is organized around a traditional subject). An example would be a course titled "Business, Industry, and the World's Environment." Core knowledge from all the natural and social sciences would need to be integrated with mathematics, language arts, and technology. Class projects would be designed to include collecting physical as well as demographic data would use various mathematical models to analyze the data. The reading and writing skills that these specific content areas demand makes the infusion of all the language arts a necessity, and the use of scientific equipment and computer technology as tools properly places the activities in a technical context. Of course, pure interdisciplinary courses nearly always require team teaching, and often they require modular flexible scheduling. Implementation presents logistical challenges as well as rewarding results.

The Competency Based Curriculum.[3] In addition to being applications based and interdisciplinary, Tech Prep courses need to be competency based. The idea behind competency based curriculum is that there are definite skills that students need if they are to be productive members of our society. These skills can be as specific as being able to use a mouse to delete text when word processing or as general as being able to work cooperatively with other individuals.

---

[3] Competency based curriculum, performance based instruction, and Mastery Learning are often used interchangeably. The three terms are closely related and imply that the curriculum is based on predetermined competencies that the student is expected to develop, that assessment is based on actual performance of the competency, and that instruction continues until performance reaches a predetermined level of mastery.

In the workplace, it is common for employers to identify skills that are specific to a job. Then they train their employees in those job specific skills. However, in schools students prepare for a variety of occupations, so teachers need to be more general in the type of performance skills they expect students to master. Some skills, such as those dealing with interpersonal communications, should be part of all Tech Prep courses. More specific skills, such as solving problems that use algebra or punctuating written communications, usually will be part of a specific course or unit.

The process followed in developing competency based curriculum can vary, but these six steps should be incorporated:

1) Identify and verify competencies;
2) Develop performance objectives;
3) Design and implement instruction;
4) Develop an accurate assessment of competencies;
5) Document student progress;
6) Review and evaluate the instruction;

For an entire Tech Prep program, the first step should be completed jointly by parents, teachers, school administrators, and local business/labor/industry representatives. Suggestions for involving concerned parties in identifying competencies that are relevant to a Tech Prep program are outlined in Hull and Parnell (1991, pp. 52-59).

Competency based instruction is widely accepted practice in industrial training programs, and teachers in technical fields have well-developed procedures for developing and managing competency based programs. One such procedure is outlined in the technology module contained in Division II. Teachers who seek specific suggestions should refer to those materials.

To the extent possible, performance objectives should be easily measured, and the "test" should be as close to real-world performance of the competency as possible. Such measurement is not easy when skills are complex. For example, a student in a Tech Prep class might be expected to write a letter to a customer explaining various options for repairing or replacing an aging furnace. A multiple-choice exam requiring students to identify punctuation errors in set sentences may meet the test of "easily measured," but it is far from the actual competence that one wishes to develop.

There is a down side to having students demonstrate competency in realistic settings. Reading and evaluating actual letters is time consuming and subjective. But, just because evaluating the quality of such a letter is necessarily subjective does not mean that writing a performance objective pertaining to letters written to customers is inappropriate. In fact, many of the skills students need most are difficult to quantify. In these cases it is better to use life-like methods of assessing performance and acknowledge their subjective nature than it is to simplify instruction to include only those skills that are easily assessed.

Behavioral objectives and other byproducts of competency based instruction have fallen out of favor with many educators in recent years because it is difficult to write higher-order objectives in explicit, behavioral terms. Many teacher educators and school administrators insisted that all statements of objectives adhere rigidly to the pattern popularized by Robert Mager (1975), and the result was often trivial objectives and even more trivial instruction. In order to place more emphasis on higher-order objectives, many educators have abandoned the language of behavioral objectives and mastery learning altogether. Furthermore, the quality of instruction in many classrooms is such that many students have been unable to master material in a reasonable length of time, and teachers have given up on mastery learning in order to "move students along." The consequence is that many students have graduated without the competencies needed to function in our modern, technological world.

Tech Prep advocates a return to competency based curricula with assessment of students' mastery of skills to be based on performance in realistic contexts. Rather than relying on short answer pencil and paper exam questions that can be easily and "objectively" scored, Tech Prep relies more on holistic evaluation of complex products (*e.g.*, oral or written reports of extensive group projects) and observation of students as they perform actual tasks (*e.g.*, construction and testing of a solar collector). Although such evaluation techniques are necessarily more "subjective" than multiple-choice exams, they do not have to be less reliable. And, they are often far more valid.

Once performance objectives are identified, the competency based curriculum model assumes that students should be allowed to continue to study until they master those objectives. Students may learn at different rates or in different ways. However, *the assumption is that all students can and will learn*. Recent research in cognitive science includes ample evidence that there is warrant for this assumption.

Curriculum Development

Developing a Tech Prep curriculum should be a school-wide, community based process. Employers, parents, faculty, and administrators all must be involved in vital discussions that revise, and in many instances reconstruct, the courses of study that will comprise Tech Prep for the school. That process, at times, is tedious, but always it must be systematic.

In Chapter 4 of Hull and Parnell (1991), Maurice Dutton describes the duties of the Curriculum Development Committee which will be responsible for developing the Tech Prep curriculum. Dutton identifies these five functions:

- [R]eview the needs of the community,
- review the current curricula,
- identify and do away with duplication,
- modify courses, as needed, and
- develop new courses and/or curricula, as needed.

(Hull & Parnell, 1991, p. 101)

Dutton's advice is excellent, and it only needs to be placed in the context of the Indiana Tech Prep model.

Review the Needs of the Community. The first function identified by Dutton is to review the needs of the community, but what is the community? For educators in Fort Wayne or Indianapolis or Evansville or any other metropolitan area, the answer may be obvious. It is not obvious in many rural areas. The industry in those areas is agriculture, and the needs of modern agriculture will be an important consideration, but many high school graduates in rural areas leave the local community for work in other areas. In many Indiana towns the major employer is located in another city--even in another state! If "community" is viewed too narrowly, needs of local students will not be met. Careful consideration must be given to business, labor, and industry representation on the curriculum development committee to ensure that the Tech Prep curriculum is not defined too narrowly.

As community needs are reviewed to identify the competencies to be developed in your Tech Prep program, the committee may save time by beginning with national and regional reports that address educational needs for the modern workplace. Changes brought about as a result of global competition have not reached many small businesses that operate at a local or regional level. Representatives from those businesses may be unaware of the implications of those changes. Beginning this process with a consideration of existing reports may help these representatives focus on needs that are likely to materialize over the next several years. Some of the reports that may be useful for this purpose are described in Appendix E.

Review the Current Curricula. The second function of the curriculum committee, according to Dutton, is to review the current curricula. Dutton's discussion focuses on articulation issues which are discussed in Chapter 6 of this manual, but there are other issues to be considered. Attention should be given to how well existing academic courses meet the needs of Tech Prep students. If virtually all students in a school are taking algebra and are developing competence that they are able to apply in science and technology, there is little point in changing what exists. However, if only students in the college-preparatory curriculum are developing competence in algebra, attention must be given to what changes need to be made to make this content accessible to a majority of the student population.

Identify and Do Away with Duplication. Indiana educators have expressed concern that implementing Tech Prep will require additional courses which schools cannot afford. Dutton suggests that careful review of the curriculum can result in a reduction in courses offered, and the SREB reports that one of the steps taken by the most suggessful schools is to "[r]emove low-level mathematics and science courses from the curriculum--Schools are replacing general math and consumer math with Algebra I or Applied Mathematics I, and general science with a lab science that is the same as or equivalent to a college prep course" (SREB, 1992, p. 130).

Modify and develop courses as needed. Dutton suggests that the last two step for the Tech Prep Curriculum Committee is to modify existing courses and develop new courses as needed. As suggesting in the following section, it may be necessary to do this in steps.

Levels of Implementation

Reform as extensive as Tech Prep calls for substantial change. It may not be possible to achieve all that is implied by the Indiana Tech Prep Model in one bold stroke. As Hull and Parnell have pointed out, "Depending on local circumstances, the development of a TPAD program may need to proceed in several steps, taking two or three years to achieve a fully articulated program" (Hull and Parnell, 1991, p. 51).

Hull and Parnell's levels. Hull and Parnell describe three levels of implementation of Tech Prep which "can be considered a 'step' in developing a full TPAD curriculum" (p. 51). The first level involves evaluating and rearranging the content of existing courses. The second involves modifying the content of selected courses to reflect needs of an articulated program, adding and deleting courses as appropriate. The third level, rewriting the entire curriculum, is required in many schools in order to achieve the goals of the Indiana Model.

Levels of technology use. Most conceptions of Tech Prep programs include an increase in the use of technology in instruction--particularly computer technology. Schools will not be able to equip classrooms with computers and other machines overnight. To assist schools in implementing Tech Prep as they acquire new equipment, the units in Division II of this manual have been written to illustrate three levels of technology utilization. The unit "Spectrophotometry" provides a good example. At the first level (low cost), principles of spectrophotometry are illustrated by using a flashlight as a light source, a test tube as a sample holder, and the human eye as the detector. The second level (moderate cost) involves the use of a locally constructed spectrophotometer which provides useful instrumentation at a cost of about $20. The third level involves the use of commercial equipment as modern as any found in the workplace. The essence of Tech Prep needs to be found first in the nature of the curriculum and the methods of instruction, and only second in the sophistication of the laboratories.

Levels of collaboration. Subject matter integration is one of the defining characteristics of Tech Prep. Whereas Hull and Parnell (1991) call for integration between vocational and academic subjects in the discussion of applied academics, the Indiana Model encourages even more integration. In the Indiana Model, integration of subjects calls for team teaching and joint instructional planning all across the curriculum. The Bar Coding module in Division II of this manual was developed through such collaboration. A technology teacher suggested bar coding as a useful vehicle for an integrated unit. He provided science, mathematics, and English teachers with information on the technology, and they considered ways to teach ideas from their disciplines through that technology. The Bar Coding module in Division II is the result. It is assumed that teachers from the various disciplines will collaborate in teaching the unit. Thus, the Bar Coding module represents a level of collaboration approaching the ideal suggested by the Indiana Tech Prep Model.

The level of collaboration implied by the Bar Coding module will be difficult to achieve in all instances. Limitations on time, incompatible schedules, personality conflicts, and other practical difficulties will get in the way. Acknowledging such matters, the teacher education materials in Division II show three levels of teacher collaboration. The language arts unit, Personal Job Search, illustrates the first level. The unit is based on strategies emphasized in Tech Prep (*e.g.*, applications based instruction, problem solving, cooperative learning, and consideration of learning styles), but it can be taught within the English curriculum without the participation of teachers from other departments. The second language arts unit, Create-A-Product, requires collaboration between an English and technology teacher. It illustrates the second level of collaboration, and Bar Coding illustrates the third.

Like the levels of Tech Prep implementation discussed in Hull and Parnell (1991), the levels of technology use and levels of collaboration illustrated in Division II may be thought of as stages of implementation to be achieved over a period of several years as teachers move from the discipline-based curriculum in place today to a highly integrated program of study that more closely approximates intellectual tasks encountered outside of school.

The levels of collaboration just described represent ways to foster subject matter integration. Subject matter integration can be achieved in a number ways. Eight models for integrating vocational and academic education, some requiring no collaboration and some requiring a great deal, are presented in Grubb, et al. (1991). Table 1 and the following summary, both taken from that document, summarize the eight models.

TABLE 1

Models of Integrating Vocational and Academic Education

	Curriculum Changes	*Teacher Changes*	*Students Targeted*	*Institutional Changes*
1. Incorporating more academic content in vocational courses	Vocational courses include more academic content	Vocational teachers modify courses	Vocational students	None
2. Combining vocational and academic teachers to enhance academic content in vocational programs	Vocational programs include more academic content, in either vocational courses or related applied courses	Academic teachers cooperate with vocational teachers	Vocational students	None
3. Making academic courses more vocationally relevant	Academic courses include more vocational content; sometimes new courses (e.g., applied academics) adopted	Academic teachers (usually) modify courses or adopt new ones	Potentially all students; in practice, vocational and general-track students	None
4. Curricular alignment: horizontal and vertical	Both vocational and academic courses modified and coordinated across courses and/or over time	Vocational and academic teachers cooperate; numbers range from two to all	Potentially all students; actual targets vary	None necessary; curriculum teams may foster cooperation

	Curriculum Changes	*Teacher Changes*	*Students Targeted*	*Institutional Changes*
5. Senior projects	Seniors replace electives with a project; earlier courses may change in preparation	None necessary; teachers may develop new courses or modify content to better prepare students	All students	None necessary
6. The Academy Model	Alignment among academy courses (English, math, science, vocational) *may* take place	Vocational and academic teachers may collaborate on both curriculum and students	Usually potential dropouts; sometimes students interested in specific occupational areas	School-within-a-school; block rostering; smaller classes; links to employers
7. Occupational high schools and magnet schools	Alignment among all courses may take place, emphasizing the occupational focus	All vocational and academic teachers assigned to an occupational school or magnet within a school; collaboration facilitated	Students interested in specific occupational areas	Creation of a self-contained occupational school or magnet school
8. Occupational clusters, "career paths," and majors	Coherent sequences of courses created; alignment may take place among courses within clusters	Teachers belong to occupational clusters rather than (or in addition to) conventional departments; collaboration facilitated	All students	Creation of occupational clusters; enhancement of career counseling; possible cluster activities

SUMMARY[4]

Efforts to integrate vocational and academic education have all the signs of a new movement. Policymakers reforming secondary vocational education, vocational educators trying to find a new relevance for their programs, business people decrying the "narrow vocationalism" of the schools, critics of academic education, and cognitive scientists developing new theories of learning have all lent their support to integration. Several states have initiated their own programs to encourage integration, including both pilot projects and some statewide initiatives. At the local level, where the most exciting developments are taking place, school districts have experimented with many different approaches.

Because those supporting integration have so many different purposes, the goals of this fledgling movement are correspondingly broad. One historically persistent view has criticized vocational education for its ineffectiveness in enhancing employment and urged more general forms of vocational education. Another strand of argument, most often associated with the business community, has criticized the deficient academic skills of many youth, especially those in vocational programs, and has insisted that secondary schools first strengthen the basic skills of their students. Vocational educators themselves, responding to declining enrollments caused by the academic emphasis of recent reforms, have suggested broader and less job-specific forms of vocational education better suited to the demands of a technological age; others, recognizing the basic skills deficiencies of their students, have begun to incorporate more explicitly remedial education in their programs. Critics of high schools, noting the large numbers of students bored by conventional academic methods, have called for new methods to invigorate secondary education, including techniques which vocational education has traditionally espoused. Cognitive scientists have reaffirmed the importance of learning in specific contexts, again suggesting that combining vocational approaches with academic content might generate more powerful results.

Because the support for integration has so many strands, and because schools differ so much in their structure, students, and labor markets, it is not always clear what efforts at integration are trying to accomplish. Based on observations in many schools, we have identified eight models of integrating vocational and academic education, each with several variations. In this variety there is an important lesson: *many approaches to integrating vocational and academic education exist, rather than a single model that could apply to all schools. It would, therefore, be misguided for federal or state policymakers to impose a single model or decide on one "best" approach.*

---

[4] Taken from Grubb, et al., 1991, pp. iii-viii

The eight models differ widely in how they approach integration and in their ambitions. The models include the following:

1. **Incorporating more academic content in vocational courses**
   Some schools have worked to incorporate more academic material into existing vocational courses, either through exhortation, through the adoption of new curriculum materials, or through the development of model curricula.

2. **Combining vocational and academic teachers to enhance academic competencies in vocational programs**
   A somewhat different approach has assigned academic teachers the responsibility of enhancing the academic components of vocational programs. Academic teachers can then teach applied academic courses modified for particular occupational areas, teach individual lessons or modules for vocational students, help vocational instructors to develop their own academic exercises, or pull students out of vocational classes to work on academic competencies. The crucial element in this approach (in contrast to the first model) is that vocational and academic teachers collaborate in modifying vocational programs.

3. **Making the academic curriculum more vocationally relevant**
   A third approach modifies the academic curriculum (instead of vocational courses) by incorporating vocational applications and reconfiguring academic courses so that the topics are more relevant to vocational students. While informal methods of encouraging these changes have been tried, a more common approach has been to introduce specific courses, especially the "applied academics" courses such as Principles of Technology, Applied Mathematics, and Applied Communication. These courses have been used in many ways: In some cases, they are clearly related to vocational purposes in a sequence of courses; while in other schools, they are simply forms of remedial education or electives unconnected to vocational education.

4. **Curricular "alignment": modifying both vocational and academic courses**

Another model combines elements from the preceding approaches, using more occupationally relevant material in academic courses and more academic education in vocational courses and then linking the two. This may happen when two or more teachers, from both the vocational and the academic sides, coordinate the content of what they teach at a particular time—what we term "horizontal alignment." In the best cases, this practice creates sequences of vocational and academic courses that reinforce each other—or "vertical alignment"—clarifying that integrating vocational and academic education can reform entire programs rather than individual courses.

5. **The senior project as a form of integration**

A few schools have instituted senior projects which often require a research paper, a physical project, and an oral presentation. Such a project forces students to integrate their learning from different courses, including the abilities learned in vocationally oriented workshops. Several schools with senior projects have found it necessary to revise their curricula in order to better prepare students for independent efforts during their senior year—that is, the senior project forces a kind of vertical alignment.

6. **The Academy Model**

Academies are schools-within-schools that typically include academic teachers in English, math, and science with a vocational instructor in a subject such as health, electronics, business, or agriculture, which gives focus to the academy. Because these teachers stay with a group of students for all four courses, over two or three years, the possibilities for both horizontal and vertical alignment are increased enormously. Academies also establish close relationships with particular firms operating in their occupational area, providing students with additional motivation, mentors, and internships.

7. **Occupational high schools and magnet schools**

In a few cities, occupational high schools focused on a cluster of occupations (e.g., health or agriculture) exist; in other cities, occupationally oriented magnet schools have been established. These institutions can provide an obvious focus for efforts to integrate vocational and academic education and a culture in which it is easier to emphasize the occupational content of coursework. They are also excellent examples of "focus schools" (Hill, Foster, & Gendler, 1990)—schools with clear missions and educational purposes— and worthy alternatives to the chaos of the conventional high school.

8. **Occupational clusters, "career paths," and occupational majors**
A few high schools have replaced vocational and academic departments with departments organized around occupational clusters. In other cases, schools have maintained conventional departments, but students and teachers are organized in "career paths" or elect occupational "majors." This creates a matrix structure in which teachers participate in both department discussions about particular vocational and academic courses, and in occupational clusters which can then develop coherent sequences of courses and align courses within each cluster. Like the occupational focus of each academy, occupational clusters facilitate cooperation among teachers, facilitate both horizontal and vertical alignment, and provide academic teachers with obvious vocational emphases to incorporate in their classes. In addition, the need to elect an occupational cluster forces students to consider more seriously their occupational futures. Clusters can also match students from different backgrounds with very different occupational ambitions, reducing the usual segregation of college-bound and vocational students.

While there has been a great deal of innovation in these approaches, other efforts have fizzled. Clearly, then, the efforts to integrate vocational and academic education require certain elements to succeed. Among the most important are the following:

- Vision and commitment, especially by individuals who can persuade others to change.
- Consistent support from district administrators and state officials, since indifference or active hostility can easily undermine the process of innovation.
- New resources, especially for release and preparation time for teachers, new materials, staff development, improved counseling services, smaller classes, and a rich variety of vocational courses.
- Sustained efforts, since a substantial amount of time is necessary for innovations that seek to reverse a division that is a century old.

- Teacher training, since vocational and academic teachers are now prepared in ways which reinforce the separation of vocational and academic education.

The approaches to integration vary considerably, ranging from marginal changes in existing courses to thorough reforms reshaping an entire high school. Their purposes also vary substantially. Some innovations aim to reform vocational programs, often by providing more remediation or academic enrichment for vocational students; some institute novel occupational programs that are highly disciplinary. In many, but not all cases, the efforts to integrate have abandoned older conceptions of vocational education as job-specific training and have shifted to a broader conception in which programs prepare students for clusters of related occupations and for both employment and postsecondary education.

A somewhat different purpose of some reforms is to assist students in the occupational decisions all adolescents must make. Many schools have recognized that enhanced guidance and counseling are necessary to help students understand the purpose of both vocational and academic offerings and to make informed decisions about their curricula—especially where they must elect an occupational cluster. In addition to increasing resources in conventional career counseling, a few schools have instituted courses exploring technologies and careers, or occupational exploration in academic courses, as ways of providing students with more substantial ways of investigating their occupational futures.

Finally, the most ambitious approaches to integration can be interpreted as efforts to reconstruct the American high school—to grapple with some of its more serious failings and to develop a vision of what secondary education should be. The important components in this reconstruction include

- eliminating the "shopping mall high school" by replacing the tendency of students to "mill around" and take unrelated courses with coherent sequences of courses related to broad occupational clusters.
- enhancing the engagement of students by replacing the stultifying teaching of conventional academic courses with more activity-based and student-initiated methods, and by clarifying the importance of education to future careers.

- improving the teaching of all subjects by replacing the teacher-driven, didactic, and decontextualized methods of most academic classrooms with the student-centered, project-oriented, and contextualized methods used in the best vocational classes.
- reducing the isolation of teachers by providing new opportunities and motives for collaboration.
- reducing tracking and segregation of students by eliminating or at least weakening the divisions between vocational and academic students.
- providing a clear vision of how business should participate in high schools to supply the kinds of motivation and incentives that teachers cannot and to stress the variety of competencies which students need to master for their occupational futures.

Integrating vocational and academic education is not necessarily an end in itself. It is instead a way of overcoming some deficiencies of the American high school, including those that developed as a result of the original division between vocational and academic subjects a century ago. It also provides a vision of what secondary education could be and an impetus for change that otherwise would not take place. Above all, the efforts to integrate academic and vocational education force us all to recognize the varied capacities—general and specific, vocational and academic, manipulative and behavioral, as well as cognitive—that successful individuals must possess. For these reasons, the effort to integrate vocational and academic education may be the best stimulus to reconstruct the American high school.

References

Gardner, M. (Ed.). (1991). Toward a scientific practice of science education. Hillside, NJ: Lawrence Erlbaum Associates.

Grubb, W., Davis, G. Lum, J., Plihal, J., & Morgaine, C. (1991). The cunning hand, the cultured mind: Models for integrating vocational and academic education. Berkeley, CA: National Center for Research in Vocational Education.

Hiebert, J., & Carpenter, T. P. (1992). Learning and teaching with understanding. In D.A. Grouws (ed.), Handbook of research on mathematics teaching and learning pp. 65-97. New York: Macmillan.

Hull, D., & Parnell, D. (Eds.). (1991). Tech prep associate degree: A win/win experience. Waco, Texas: Center for Occupational Research and Development.

Kloosterman, P., & Gainey, P.H. (in press). Students' thinking: Middle school mathematics. In D. Owens (Ed.), Research ideas for the classroom: Middle grades mathematics. New York: Macmillan.

Mager, R.F. (1975). Preparing instructional objectives (rev. ed.). Belmont, CA: Fearon-Pitman Publishers, Inc.

Pedrotti, L., & Parks, D. (1991). A solid foundation: the role of applied academics. In D. Hull & D. Parnell (Eds.), Tech prep associate degree: A win/win experience. Waco, Texas: Center for Occupational Research and Development.

Resnick, L. (1987). Education and learning to think. Washington, DC: National Academy Press.

Southern Regional Education Board (SERB) State Vocational Education Consortium. (1992). Making high school work: Adding purpose and focus to secondary schools through integration of academic and vocational education. Draft report prepared by the State Vocational Education Consortium, 592 Tenth Street, NW, Atlanta, GA.

Tobias, S. (1990). They're not dumb, they're different: Stalking the second tier. Tuscon: AZ: Research Corporation.

CHAPTER 4

INSTRUCTIONAL STRATEGIES FOR TECH PREP

By

James Green
Professor of Secondary Education
Department of Secondary, Higher, and Foundations of Education
Ball State University

and

Amy Mendenhall
Graduate Assistant
Department of Secondary, Higher, and Foundations of Education
Ball State University

Abstract

This chapter describes the instructional strategies that characterize Tech Prep. Among the topics discussed are problem solving, cooperative learning, and learning styles. This chapter will be of particular interest to classroom teachers who will be developing or teaching Tech Prep courses.

Indiana Tech Prep Training Manual: Division I
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

INSTRUCTIONAL STRATEGIES FOR TECH PREP

Introduction

The workplace in the 21st century will be unlike any other we have known. It will be global because commerce will be conducted in an international arena, and workers will be held to world class standards of excellence. It will be technological because increasing demands on shrinking resources will require even more rapid advancements in technologies for industries and businesses to remain productive and competitive. It will be interdependent because sophisticated technologies require complex systems comprised of human resources. These three conditions--global, technological, and interdependent--call for educators to focus again on skills that are essential for political freedom and economic vitality.

In 1991 the United States Secretary of Labor commissioned a comprehensive study on what the workplace of the future requires of schools today. The report (SCANS, 1991) identified a three part foundation for a curriculum to prepare tomorrow's workforce (Figure 1). Further, the SCANS Report outlined five competencies required for the next generation of workers (Figure 2).

These competencies required of 21st century workers call for renewed attention to instructional methodologies that more closely fit the modern workplace. Applying general knowledge and basic skills to novel and specific situations; learning to cooperate by communicating with others and sharing responsibility and accountability to complete tasks; thinking critically to solve problems; and recognizing and employing the variety of learning styles all form the nucleus of instructional strategies a teacher must employ for the new demands of Tech Prep curriculum.

In this chapter four general areas of instructional strategy are outlined. The first, *applications based instruction*, stresses the importance of designing instructional activities that resemble the actual tasks and environments of the modern workplace. The second, *learning styles*, enables teachers to design lessons in a manner that acknowledges the differences in the way individuals learn best. The third, *cooperative learning*, provides for learning to occur as the product of people working together to reach common goals, just as they must do in the workplace. The fourth, *problem solving*, is inclusive of all the other three. Planning for students to think critically in both verbal and analytical contexts to solve problems will be the central element in the Tech Prep classroom.

All four areas of Tech Prep instructional strategies--applications based instruction, learning styles, cooperative learning, and problem solving--emerge from the characteristics of the 21st century workplace. The strategies converge to become the Tech Prep curriculum. (Figure 3).

Applications Based Instruction

Applications based instruction integrates all of the features of Tech Prep. It is performance based instruction dealing with real world scenarios or simulated real world scenarios. The usual focus for these scenarios is the workplace. Sawyer (1986) states, "Hands on experience in real world settings allows students to reach into their storehouse of potential and explore abilities; it expands their realm of thought so they can see the practical

83

Figure 1

A THREE-PART FOUNDATION

Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks

A. *Reading*: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules
B. *Writing*: Communicates thoughts, ideas, information, and messages, in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts
C. *Arithmetic/Mathematics*: Performs basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques
D. *Listening*: Receives, attends to, interprets, and responds to verbal messages and other cues
E. *Speaking*: Organizes ideas and communicates orally

Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn, and reasons

A. *Creative Thinking*: Generates new ideas
B. *Decision Making*: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative
C. *Problem Solving*: Recognizes problems and devises and implements plan of action
D. *Seeing Things in the Mind's Eye*: Organizes, and processes symbols, pictures, graphs, objects, and other information
E. *Knowing How to Learn*: Uses efficient learning techniques to acquire and apply knowledge and skills
F. *Reasoning*: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem

Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

A. *Responsibility*: Exerts a high level of effort and perseveres towards goal attainment
B. *Self-esteem*: Believes in own self-worth and maintains a positive view of self
C. *Sociability*: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings
D. *Self-management*: Assesses self accurately, sets personal goals, monitors programs, and exhibits self-control
E. *Integrity/Honesty*: Chooses ethical courses of action

side of theoretical subject matter and put the...basics to work." The SCANS (1991) report further emphasizes that the most effective way of learning a skill is "in context" by placing learning objectives within a real environment rather than insisting that students first learn in the abstract what they will be expected to apply. Applications based instruction reverses the traditional sequence of instructional events. Rather than theory followed by application, application precedes theory. Rather than abstract to concrete, the students are led from the concrete to the abstract (Cassell & Sutley, 1991).

Figure 2

FIVE COMPETENCIES

Resources: Identifies, organizes, plans, and allocates resources

A. *Time*: Selects goal-relevant activities, ranks them, allocates time, and prepares and follows schedules
B. *Money*: Uses or prepares budgets, makes forecasts, keeps records, and makes adjustments to meet objectives
C. *Material and Facilities*: Acquires, stores, allocates, and uses materials or space efficiently
D. *Human Resources*: Assesses skills and distributes work accordingly, evaluates performance and provides feedback

Interpersonal: Works with others

A. *Participates as a Member of a Team*: Contributes to group effort
B. *Teaches Others New Skills*
C. *Serves Clients/Customers*: Works to satisfy customers' expectations
D. *Exercises Leadership*: Communicates ideas to justify position, persuades and convinces others, responsibly challenges existing procedures and policies
E. *Negotiates*: Works toward agreements involving exchange of resources, resolves divergent interests
F. *Works with Diversity*: Works well with men and women from diverse backgrounds

Information: Acquires and uses information

A. *Acquires and Evaluates Information*
B. *Organizes and Maintains Information*
C. *Interprets and Communicates Information*
D. *Uses Computers to Process Information*

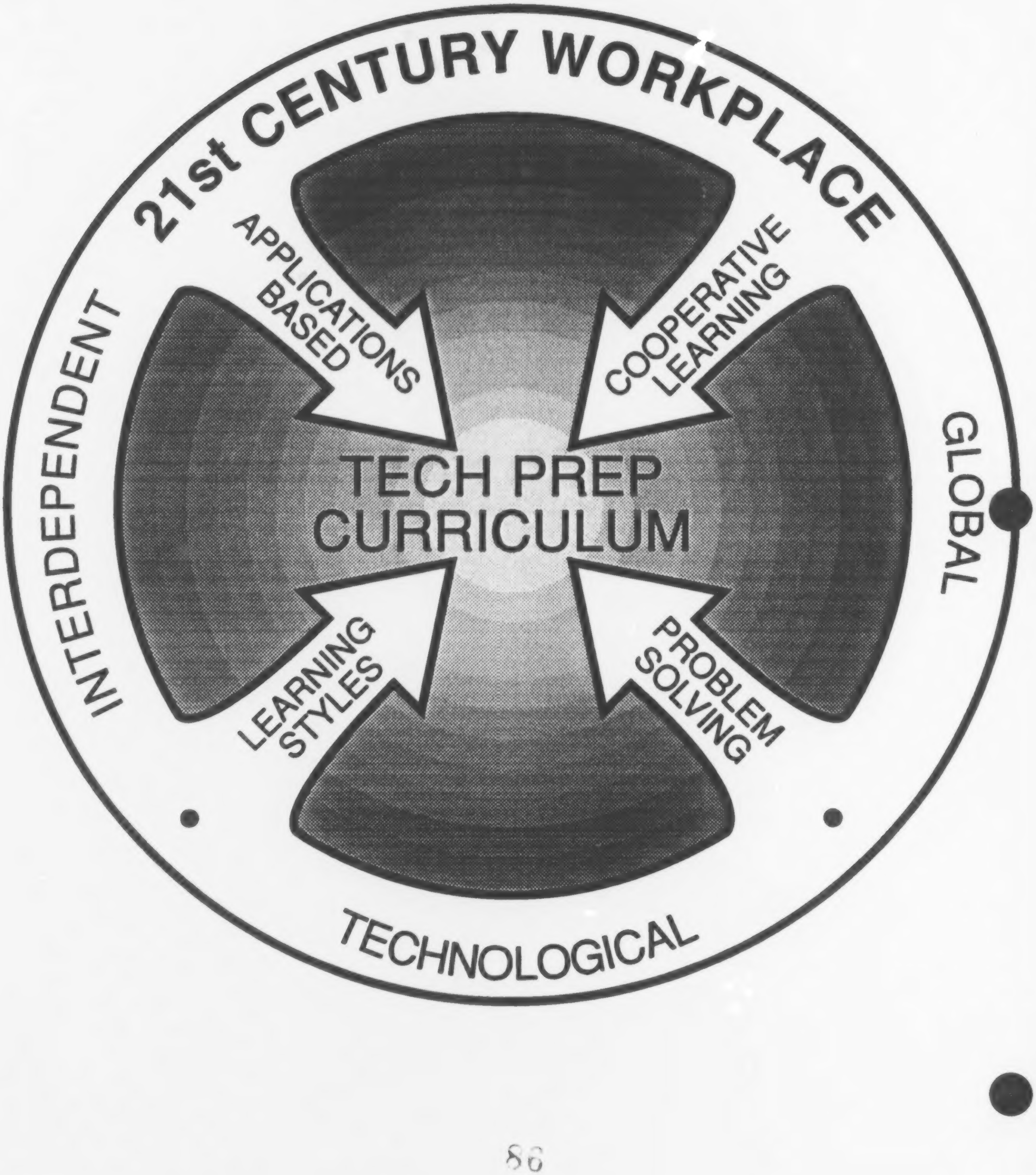
Systems: Understands complex inter-relationships

A. *Understands Systems*: Knows how social, organizational, and technological systems works and operates effectively with them
B. *Monitors and Corrects Performance*: Distinguishes trends, predicts impacts on system operations, diagnoses systems' performance and corrects malfunctions
C. *Improves or Designs Systems*: Suggests modifications to existing systems and develops new or alternative systems to improve performance

Technology: Works with a variety of technologies

A. *Selects Technology*: Chooses procedures, tools, or equipment including computers and related technologies
B. *Applies Technology to Task*: Understands overall intent and proper procedures for setup and operation of equipment
C. *Maintains and Troubleshoots Equipment*: Prevents, identifies, or solves problems with equipment, including computers and other technologies

TECH PREP INSTRUCTIONAL STRATEGIES
Figure 3


21st CENTURY WORKPLACE
INTERDEPENDENT
GLOBAL
TECHNOLOGICAL
APPLICATIONS BASED
COOPERATIVE LEARNING
TECH PREP CURRICULUM
LEARNING STYLES
PROBLEM SOLVING

In applications based instruction subjects are integrated as they are in the real world, rather than separated into discrete disciplines. Baker, Grubbs, and Barnhart (1989) suggest that teachers need to interact with other areas of knowledge, and they suggest that a holistic approach must be developed rather than one based on fragmented theory. They elaborate that students need to understand the applications of physics, chemistry, math, and other fields with respect to technological systems.

Applications based instruction includes the instructional strategies of problem solving, learning styles, and cooperative learning. Problem solving is used throughout task performance. Knowledge is acquired, practiced, and tested through application. Students' different learning styles are addressed. Applications are provided in a variety of media, styles, and contexts. Students apply knowledge and skills during interpersonal contacts through cooperative learning groups.

There are many benefits to using applications based instruction. It is active, rather than passive, and it motivates through direct student involvement. Theory becomes practical as the applications provide meaning and relevance. Understanding is strengthened and deepened by the hands-on experience which leads to an increase in learning retention. The knowledge becomes useful and important, and the learning transfers more effectively to the real world (Cassell & Sutley, 1991).

A major finding of the SCANS (1991) committee is that real know-how cannot be taught in isolation and that students need practice in the application of skills. As a result of their research, the committee developed five competencies (Figure 2) that are part of what is needed for solid job performance. The skills needed to use and manage resources, technology, and systems encompass many aspects of applications based instruction. Workers need to know how to use materials and space efficiently and effectively. They must also be able to use computers to process information. They must understand, monitor, and improve systems as needed. This includes technological systems. To be effective, all workers must be able to select, apply, and maintain technological procedures, tools, and equipment.

Examples of applications based instruction are provided in the units in Division II. The science unit, Robotics, includes the use of robot software as one of the activities. The use of real bicycles in the mathematics unit, Ratios, to teach the concept of distance gives the students real-life objects they can relate to. The Ratios unit further suggests the use of CAD software to draw circles and make measurements and spreadsheet software to create tables and test relationships. The technology units on material handling and drafting/CAD both present real-world problems to be solved. In "Create-A-Product," an English unit that is designed for implementation in conjunction with a manufacturing class, the students use a Macintosh computer to design ads and a Rhino robot and Emco Meir CNC lathe to manufacture their products. All of these examples situate learning in a real-world environment.

Steen (1989) points out that today's students will live and work in the 21st century in an era dominated by computers, worldwide communication, and a global economy. Technology is constantly changing and being improved upon. This is why all students must have experience in applying their knowledge in real world situations. They must be ready to adapt to new technology, equipment, and situations. Applications based instruction helps students transfer their learning more effectively to the real world.

Learning Styles

One reason that teaching is so difficult is that we don't know enough about all of the factors that affect learning. We know that all people are different, but we can't agree on exactly how they are different, what these differences mean, and consequently, how they should be educated. Two basic and very valuable components of the learning process are the individuality of the student and the individuality of the teacher. This individuality can interfere with achievement unless teachers consider learning style preferences when planning classroom lessons.

Focusing on learning styles is one way to expand teaching methods and curricula to reach more students. Learning styles are the unique ways whereby an individual gathers and processes information and are the means by which an individual prefers to learn (Davidson, 1990). Learning styles indicate how a student learns best.

James Keefe, an expert on learning styles at the National Association of Secondary School Principals, defines learning styles as "characteristic cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact, and respond to the learning environment" (O'Neil, 1991). Cognitive variables are perceptual controls or frames and include such things as the need for structure, selective attention, and whether hypotheses and decisions are made reflectively or impulsively. Affective variables are motivational biases or preferences and include emotional and personality characteristics related to areas such as achievement motivation, persistence, and the propensity for taking risks. Physiological variables are bodily states or predispositions and include preferences for a certain time of day, the need for mobility, and responses to environmental elements such as sound, light, and temperature (Keefe, 1986).

There are currently over 100 existing instruments that have been developed by researchers and educators to assess the different dimensions of learning styles (Curry, 1990). Some people may be bothered by the fact that learning style advocates such as Rita Dunn, Anthony Gregorc, and Bernice McCarthy view style differently and make conflicting recommendations for practice. Each of these models may vary in length, format, complexity, and terminology, but the central theme that individuals are different and learn differently is the same. The indication, then, is that one learning format will not be right for everyone in the classroom. The majority of practitioners have thus concentrated on diversifying the learning environment to respond to student learning style differences.

Whatever learning style model is chosen, teachers need to make sure that all students are exposed to a variety of teaching strategies that foster academic success and lead to more positive self-concepts. Research indicates that teachers tend to teach the way they learn, and that the most successful students in a classroom happen to have learning preferences that match the learning preferences of the teacher (Campbell, 1991). Teachers should use diverse strategies, not just those they prefer. Bernice McCarthy, developer of the 4MAT approach to style-based instruction, says "A teacher has a responsibility as a professional to go out of his or her style." She adds that by planning lessons with style in mind, teachers "give the majority of kids a better chance" (O'Neil, 1991).

Each unit in Division II of this manual is designed to be adjustable to students' optimal learning styles or situations. The Personal Job Search Unit for English implements diverse teaching strategies which would appeal to different students' learning styles. In this unit students learn through various formats, including writing, listening, speaking, and using computers. The science unit, Robotics, also exposes students to different learning formats and environments including a visit to a local technology firm to view the uses of technology. At some point each of the units have students working in groups. The various roles the students can assume as group members also lend themselves to accommodating different learning styles.

The use of learning styles based instruction in the classroom can have many positive effects. Students learn to understand and value themselves and others. They are taught how to learn so that they can, in turn, teach themselves. The Secretary's Commission on Achieving Necessary Skills (SCANS) identified self-esteem and self-management as two personal qualities that employers consider to be essential. Providing students with information on their styles of learning assumes that the more students know about themselves, the better they are able to adjust to new situations (Davidson, 1990). Teachers should include their students' assessments of learning styles and plan for individual feedback. Since the science of learning style assessment is new and constantly changing, the teacher should consult with a school psychologist or guidance counselor for assistance in selecting appropriate instruments.

The SCANS report (1991) also points out that one of the aspects of thinking skills is "knowing how to learn." Students should be taught how to learn so that they can in turn teach themselves. The importance of developing metacognitive skills, or the ability to self-monitor, self-evaluate, and self-reinforce, has been stressed by educators in all disciplines. The knowledge of one's own cognitive processes can be an aid in improving any learner's academic achievement. This includes the learning or awareness of personal learning styles in order to better apply and adapt new knowledge and skills in both familiar and changing situations.

Cooperative Learning

Cooperative learning is a method of classroom instruction where students work in small groups to help one another master academic material. Vincent Lunetta (1990) reports that reviews of research studies on cooperative learning have shown very positive results. Cooperative learning promoted greater achievement than competitive or individualistic experiences. There was greater achievement when the learning tasks were more difficult and involved problem solving and divergent thinking, and students at all achievement levels enhanced their information retention and development of specific skills and strategies. Cooperative learning also promoted higher motivation to learn. Students exhibited more positive attitudes toward the instructional experiences, the instructors, their peers, and about themselves.

It is important to realize that in order to achieve the positive effects of cooperative learning, certain guidelines must be followed. Simply putting your students in groups and having them answer a set of questions is not cooperative learning. Just because individuals are configured in a circle does not mean they will become good communicators.

Opinions differ, but most teachers who use cooperative learning recommend that the teacher form the groups rather than allowing students to group themselves (Nelms, 1990; Webb, 1985). The instructional task, the age of students, and other variables affect the optimal number to ensure good group dynamics, but effective groups generally range in size from four to six. This allows the teacher to place one high achiever, one low achiever, and two to four average achievers in each group (Foyle, 1990).

Different teachers have their own methods of choosing who to place into groups. The key is to be flexible in group assignments and to monitor the progress of groups throughout the term. The group compositions that work best over the short term may not be the best ones for the long term, so professional judgment should be used to adjust the size and composition of the groups to ensure maximum performance.

A mistake that is often made when attempting to implement cooperative learning in the classroom is assuming that students know how to work together in a group. We ignore teaching the mechanics of small-group processing and race right to the problem and solution. Dana Herreman, an English teacher at Newark High School in Newark, Ohio, points out that students won't learn good group skills without specific, structured instructional training (Golub, 1988).

Robert Slavin (1991) suggests that two elements must be present in order for cooperative learning to be effective. They are group goals and individual accountability. These are what motivate students to give explanations and take each other's learning seriously. In studies of the effects of cooperative learning on achievement, 37 of 44 studies showed significant positive achievement effects where group goals and individual accountability were present. On contrast, only four of 23 studies lacking group goals and individual accountability found positive effects on student achievement (Slavin, 1991). When the group's task is to ensure that every member learns something, it's in the best interest of each group member to spend time explaining concepts to the other members of the group. Studies have consistently found that students who gain the most from cooperative work are those who give and receive elaborate explanations (Webb, 1985).

Traditionally, schools have prepared students to compete as individuals. The secondary English and mathematics classrooms, for example, have focused on recitation, drill, and individual reading as the primary means of teaching. However, leaders in business and industry are now calling for employees with teamwork skills as documented by the SCANS (1991) report. The results and outcomes of cooperative learning are directly correlated to each of the three parts of the foundation identified in the SCANS report (Figure 1) and to the competency of having the ability to productively use interpersonal skills (Figure 2). The first part of the foundation is referred to as the basic skills and includes listening and speaking skills. By ensuring that each individual is accountable for what goes on in the group, the students are forced to listen to what the other group members are saying and to participate and express their own ideas by orally communicating. Students who may feel intimidated to speak out in class seem to show an increase in self-confidence in smaller group settings. Through practice alone these skills are being refined.

The second part of the foundation is labeled thinking skills, which includes creativity, decision-making, reasoning, and problem-solving. When there are group goals present in cooperative learning, the group members must come to a consensus or group decision through reasoning and problem-solving. When group members are building on each other's ideas, their outcomes and solutions tend to be more creative. Thus, through exposure to the elements of reasoning and problem-solving through consensus, the students are developing thinking skills.

The third part of the foundation is referred to as personal qualities, and it includes responsibility, self-esteem, and sociability. When individual accountability is present in cooperative learning, students have to take responsibility to have a certain ownership in what is happening in their groups. Studies have shown that cooperative learning increases self-esteem and self-concept (Slavin, 1991). One of the earliest findings by Robert Slavin (1991) was that people who learn cooperatively learn to like one another. Liking the people you're working with increases sociability and even expands it outside of just one classroom.

Cooperative learning groups are effectively used in each of the prototype units provided in Division II of this manual. The math unit, Ratios, suggests group sizes of three to four. This is consistent with previously stated findings that the ideal group size should be around four to six. The English unit, Create-A-Product, implements the elements of individual accountability and group goals through the use of sign-off sheets and grading procedures. For example, on Day 3 before the written description of the product is turned in, each of the students' ideas must be blended into one document (the group goal), but each individual's rough draft must be turned in as well (individual accountability).

One of the competencies identified by SCANS is the ability to productively use interpersonal skills. The main feature of cooperative learning is that its structure is one that allows students to talk, but with the purpose of solving a problem or completing a task. It is through this that much of the learning takes place. Students are assimilating ideas and information through their interaction with others. The better they are able to use these interpersonal skills, the better the group will function together.

Problem Solving

Problem solving is central to Tech Prep. Students must learn to value their own ideas and to defend as well as question their interpretations when faced with alternative or opposing views. This development is counter to what most students are asked to do in school. On average, students answer multiple choice test-type questions where they are expected to immediately come up with the right response 47 times each day they're in school (Pearson, 1989).

According to Hayes (1981), if "there is a gap between where you are now and where you want to be, and you don't know how to cross that gap, you have a problem." Although several different models of problem solving have been developed, each one builds upon the same general ideas. Common to all of the models are the concepts of problem definition, analysis, trial, and evaluation (Cassell & Sutley, 1991). For example, Polya's problem solving model outlines three stages which good problem solvers use: understanding the problem, designing the plan, and looking back (Polya, 1957).

It is important to note that the steps or stages of problem solving are not well defined or clearly ordered. In fact, just the opposite is true as they differ each time a new problem is approached or a different problem solver attempts the problem. Good problem solvers use many general strategies, or heuristics, to guide them in the solution process.

The problem solving process has aspects of convergent and critical thinking all along the way (Lundsteen, 1986). Critical thinking is characterized by the conscious use of criteria, or standards, which may be either internal or external. The significance of using critical thinking is stressed in several famous works, including Bloom's Taxonomy of Educational Objectives (1956).

Researchers agree that students need to be provided with problem solving lessons in meaningful learning contexts for critical thinking to take place (Alvarez, 1990). This depends on careful, conscious preparation, organization, direction, and verification on the part of the teacher. Case-based learning, or case studies, is one method that can be used to foster critical thinking.

When students learn to make judgments and decisions based on good evidence, it seems likely that this process will have application outside of school and later in their lives (Court, 1991). The idea of application outside of the classroom is embedded in the concept of Tech Prep. The use of problem solving models within the classroom develops a variety of transferable skills. Basic workplace skills identified by the SCANS report include reading and listening skills. Paul, Binker, Martin, and Adamson (1989) state that two of the dimensions of critical thinking are reading critically and listening critically. Other dimensions include making interdisciplinary connections and comparing and contrasting ideals with actual practice. These two dimensions are basic underlying principles of Tech Prep.

The thinking skills identified by SCANS (1991) are creativity, decision-making, reasoning, and problem-solving. These skills are all interrelated. Problem solving is optimally creative when it employs a balance of divergent and convergent (or critical) thought while moving toward a goal. Lundsteen (1986) warns that the divergent or creative aspects of the problem should be worked first. This allows the student to nurture these ideas while avoiding killing the needed brainstorming portions of creative problem solving by stepping in too early with critical judgment. It should be noted, however, that the creative and the critical thinking aspects of problem solving are equally important.

The SCANS report (1991) further points out that an aspect of thinking skills is "knowing how to learn." Some believe this skill is the one which all other necessary workplace skills are based upon (Carnevale, 1990). According to Richard Paul et al. (1989), through critical thinking in problem solving students learn to think by thinking and learn to learn by learning.

The several Tech Prep units that are contained in Division II include problem solving as a prominent instructional strategy. The English unit, Create-A-Product, is designed to show that group problem solving skills are used in every phase of the business of creating a product and producing it. The students must employ creative and critical thinking skills to create, produce, and market their own product. The math lesson on scale drawing uses the case-based method of problem solving. Each group is asked to solve a problem in the meaningful learning context of Al and his need to understand maps. An individualized problem solving task is given in the science unit, Robotics. Each student is expected to create a product of his or her own design using Scorbot Robot and Scorbot Level 3 Language. It is pointed out that the product design process in the technology unit on material handling is a problem solving journey.

In summary, entry-level workers are increasingly expected to think critically, solve problems that require several steps, and apply their knowledge and skills in new contexts. All of these skills are ones that can be developed through the implementation of problem solving in the classroom.

References

Alvarez, M. C. (1990, November). Case-based instruction and learning: An interdisciplinary project. Paper presented at the Annual Meeting of the College Reading Association, Nashville, TN.

Baker, G., Grubbs, B., & Barnhart, J. (1989). Mechatronics: Technology education's future. Industrial Education, 78(9), 18-21.

Bloom, B. S. (1956). Taxonomy of educational objectives. NY: David McKay.

Campbell, B. J. (1991). Planning for a student learning style. Journal of Education for Business, 66(6), 356-359.

Carnevale, A. P. (1990). Workplace basics: The essential skills employers want. Alexandria, VA: American Society for Training and Development.

Cassell, S., & Sutley, A. (1991). A manual to facilitate the training of school personnel in the concepts and methodologies of the Indiana Tech Prep model. Unpublished training manual, Indiana Department of Education, Indianapolis, IN.

Court, D. (1991). Teaching critical thinking: What do we know? Social Studies, 82(3), 115-119.

Curry, L. (1990). Learning styles in secondary schools: A review of instruments and implications for their use. (Grant No. G-008690007-90). Madison, WI: University of Wisconsin, Center for Education Research. (ERIC Document Reproduction Service No. ED 317 283)

Davidson, G. V. (1990). Matching learning styles with teaching styles: Is it a useful concept in instruction? Performance and Instruction, 29(4), 36-38.

Foyle, H. (1990). Cooperative learning--part 2: The classroom teacher. Kansas ASCD Record, 8(4).

Golub, J. (1988). Focus on collaborative learning. Urbana, IL: National Council of Teachers of English.

Hayes, J. R. (1981). The complete problem solver. Philadelphia: The Franklin Institute Press.

Keefe, J. W. (1986). Assessment of learning style variables: The NASSP task force model. Theory Into Practice, 24(2), 138-144.

Lundsteen, S. W. (1986, November). Critical thinking in problem solving: A Aperspective for the language arts teacher. Paper presented at the Annual Meeting of the National Council of Teachers of English, San Antonio, TX.

Lunetta, V. N. (1990). Cooperative learning in science, mathematics, and computer problem solving. In M. Gardner (Ed.), Toward a scientific practice of science education (pp.235-249). Hillsdale, NJ: Lawrence Earlbaum Associates, Inc.

Nelms, B. F. (1990). Cooperative learning in English (The round table). English Journal, 76(6), 74-77.

O'Neil, J. (1990). Making sense of style. Educational Leadership, 48(2), 4-9.

Paul, R., Binker A. J. A., Martin, D., & Adamson, K. (1989). Critical thinking handbook: High school. Rohnert Park, CA: Sonoma State University, Center for Critical Thinking and Moral Critique. (ERIC Document Reproduction Service No. ED 325 805)

Pearson, P. D. (1991). Assessing literacy. Salt Lake City: Utah State Reading Council.

Polya, G. (1957). How to solve it: A new aspect of mathematical method (2nd ed.). Princeton, NJ: Princeton University Press.

Sawyer, D. E. (1986). Hands-on labs in an academic high school. Vocational Education Journal, 61(4), 50-52.

Secretary's Commission on Achieving Necessary Skills. (1991). What work requires of schools: A SCANS report for America 2000. Washington, DC: U.S. Department of Labor. (ERIC Document Reproduction Service No. ED 332 054)

Slavin, R. E. (1991). Synthesis of research on cooperative learning. Educational Leadership, 48(5), 71-82.

Steen, L. A. (1989). Teaching mathematics for tomorrow's world. Educational Leadership, 7(1), 18-22.

Webb, N. (1985). Verbal interaction and learning in peer-directed groups. Theory Into Practice, 24(1), 32-39.

CHAPTER 5

ARTICULATION

based on contributions from

Ellen Bardole
Vincennes University

Nancee Hedrick
Indiana Vocational Technical College
Terre Haute

Robert Neth
Purdue University Statewide Technology
Columbus

Abstract

This chapter contains suggestions for developing articulation agreements between secondary and postsecondary institutions.

Indiana Tech Prep Training Manual: Division I
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

ARTICULATION

ar·tic·u·late *adj., v.* . . . **6.** organized into a coherent or meaningful whole: *an articulate system of philosophy.* . . .**11.** to bring the various parts of (a work of art, a field of perception, a system of thought, etc.) into a meaningful or coherent relationship. **12.** to unite by a joint or joints (Stein, 1975)

Introduction

As Hull and Parnell (1991) point out in the first two chapters of Tech Prep Associate Degree: A Win/Win Experience, Tech Prep is a program that begins in secondary school and continues in a postsecondary institution. If it is to succeed, the parts of the Tech Prep at the two institutions must be brought into a meaningful and coherent relationship; there must be articulation. Articulation has come to mean many things in the context of Tech Prep. To some it implies giving college credit for work done at the secondary level; to others it means coordination of programs to avoid duplication. Con and Hardy describe articulation as a process, an attitude, and a goal:

> As a *process,* articulation is the coordination of policies and practices among sectors of the education system to produce a smooth flow of students from one sector to another. As an *attitude,* it is exemplified by the willingness of educators in all sectors to work together to transcend the individual and institutional self-interest that impedes the maximum development of the student. As a *goal,* it is the creation of an educational system without artificial divisions, so that the whole educational period becomes one unbroken flow, which varies in speed for each individual, and which eliminates loss of credit, delays and unnecessary duplication of effort. (cited in Hull & Parnell, 1991, pp. 42-43)

Principles of Articulation

Beyond Articulation: The Development of Tech Prep Programs, one of the books assumed to be available to readers of this manual, discusses the articulation process in detail (Dornsife, 1992, pp. 83-87). The ten principles of articulation presented by Dornsife provide a useful framework for discussion of articulation in Indiana.

Leadership and Commitment. Unless key administrators and governing boards in both secondary and postsecondary institutions are committed to Tech Prep and provide leadership for its development, effective articulation will be difficult. Enactment by the Indiana General Assembly of P.L. 217 in 1987 and P.L. 19 in 1992 make clear that there is political support for Tech Prep at the state level, but that support has not always transferred to the local level. Many school superintendents and principals, college presidents and deans, know little about Tech Prep and have not given the program high priority. Informing key individuals of the nature and importance of Tech Prep is an important step toward effective articulation.

Early Faculty Involvement. Articulation agreements have implications for what is taught at both the secondary and postsecondary levels. Faculty who teach the articulated courses are in the best position to judge what can and should be done to make the transition from secondary to postsecondary courses smooth. Courses at the secondary level must be designed so that students have competencies required for entry into postsecondary courses or entry into the work force. In Indiana, postsecondary institutions have faculty teams who will work with secondary faculty teams to insure that competencies at both levels are met.

Respect and Trust. There is little direct contact between faculty and administrators at secondary and postsecondary institutions. As a result, their conceptions about programs and colleagues at the other level are often dated and incorrect. Through collaborative efforts misconceptions can be corrected, and the respect and trust needed for successful articulation can be developed. Provision for such collaborative efforts should be made early in the development of Tech Prep programs.

Mutual Benefits To All Parties. When faculty and administrators are asked to collaborate in the development of a Tech Prep program, emphasis should be placed on the benefits of Tech Prep for all concerned. For example, articulation of Tech Prep programs can improve student recruitment, enhance public relations, and, above all, serve students better. Such positive benefits should be stressed.

Written Articulation Agreement. Most organizations have agreements at both the institutional and program level. The institutional agreement is normally signed by the chief executive officer of the schools and colleges; the program agreement is normally signed by department heads. Several examples of written agreements are shown in Appendix Q of Dornsife (1992) and the written agreement between Indiana Vocational Technical College--Northcentral and School City of Mishawaka is Appendix F of this manual.

Articulation is easiest when it involves a single secondary school corporation and a local college that enrolls a significant number of graduates from that school. In Indiana that situation will be uncommon. Indiana has no statewide community college system. Some communities have no postsecondary institution in the immediate area while others have immediate access to two or more postsecondary institutions. Most metropolitan areas are served by several secondary school corporations. Consequently, most secondary schools will need to articulate with several postsecondary institutions and vice versa. A college that draws students from everywhere in the state (e.g., Vincennes University) will not be able to draw up different agreements with all 350 Indiana secondary schools and uncounted out-of-state schools from which it draws students. That college will need some kind of standard agreement. Similarly, a school with students wishing to continue a medical technology program in any one of several postsecondary institutions that offer such programs will find articulation difficult unless there is some standardization. These problems must be addressed as Tech Prep is implemented in Indiana, the Tech Prep statewide coordinator and Tech Prep regional coordinators can foster the development of Tech Prep by encouraging regional or statewide articulation patterns.

Open, Clear, and Frequent Communication. In discussing articulation, Belcher states that "[articulation] is the most time-consuming task in the process of establishing a TPAD program. Articulating curricula could take up to six months or more, depending on what kind of relationships and interaction have existed between the two institutional levels in the past" (Belcher, 1991, p. 133). There currently exist no institutionalized processes for ongoing communication between faculty and administrators at the secondary and postsecondary levels. It will be difficult to sustain communication over a long period without them. Once again, state and regional leadership is needed to establish mechanisms for such ongoing dialogue.

Modest Initial Goals. Problems such as the need for standardization described under **Written Articulation Agreement** tend to immobilize. However, such problems are usually solved a step at a time rather than in one fell swoop. If each secondary and postsecondary institution will concentrate on articulation of a single program with a single institution, the process can begin. As modest, initial goals such as this are achieved, means for solving more intractable problems are likely to be found. Communication among institutions about initial, modest articulation agreements can eventually result in a degree of standardization that will make extensive articulation of programs manageable.

Accountability. Someone at both the secondary and postsecondary level must be responsible for articulation in order to keep agreements current. Since programs at both the secondary and postsecondary levels change from one year to the next, systematic review of agreements will be required. Someone must be responsible for ensuring that takes place.

Competency Based Curricula. The competency based curricula called for by the Indiana Tech Prep Model will facilitate articulation. Competency statements clarify what is to be taught at both the secondary and postsecondary levels, making it easier to identify program overlap and gaps.

A Common Focus on Mutual Goals Rather Than On Individual Turf. At the heart of the articulation effort is what is best for students. Educational institutions, business and industry, and the community as a whole will benefit indirectly, but the most direct benefit is to the student. So long as the focus is what is best for students, turf should not be an issue.

Appendix R in Dornsife (1992) provides a step-by-step outline for successful articulation, and the Mishawaka High School Tech Prep Information Packet, available from the Mishawaka Demonstration Site, contains specific suggestions for working out articulation agreements so that turf battles do not occur.

Process of Articulation

There are many issues that must be resolved in the process of articulation, and the more institutions involved the more complicated the process is likely to be. Padden (1991) provides a good description of the process followed by the State Center Community College District in California. The process involved twenty-three high schools, two regional occupations programs, and two community colleges. Padden reports that "[t]he major sticking point was that of issuing college credit for a course taught in high school" (p. 184), an issue that may be difficult to resolve in Indiana as well.

Advanced placement or credit. There is considerable controversy in Indiana over granting advanced standing and/or postsecondary credit for courses taken at the secondary level. There are emotional and substantive issues. Program accreditation is important to postsecondary institutions, and granting credit for courses that are not controlled by the institution can be a problem. Prestige is important to secondary schools, and awarding postsecondary credit or advanced placement affords prestige. Refusal by a postsecondary institution to award credit for a course that is considered to be of equal or higher quality than a required postsecondary course is insulting to secondary personnel. Similarly, insistence by secondary schools that credit should be granted for a course that is perceived to be inferior disturbs postsecondary personnel.

Controversy and misunderstanding are more easily avoided when courses are competency based. If competencies for both secondary and postsecondary courses are clearly stated, it is relatively easy to judge whether the two courses are, in fact, equivalent.

According to Dornsife, "most institutions follow a similar process as exemplified by Chemeketa Community College (Salem, Oregon). . . . In order to receive transcripted credits, junior and senior high school students must earn either an 'A' or 'B' *on a test administered by the community college* and then enroll in at least a three-credit course within one year of graduation" (1991, p. 34, emphasis added). In skill competence courses (e.g., keyboarding, drafting, computer drawing) competency lists can be the basis for awarding credit. Dornsife (1992, Appendix I) provides an example of a drafting technology competency profile developed at Chemeketa. This profile lists competencies required for credit in Machine Computer Drafting I, Basic Architectural Drafting, and Introduction to Computer Drawing. High school instructors check off competencies as the student completes them and indicate the high school course where each competency is taught. When the student has completed all competencies, the instructor, student, and Chemeketa Drafting Program Coordinator sign the competency profile to indicate that credit should be awarded.

Stages of articulation. As indicated in Chapter 3, Tech Prep is a complex reform effort. Given that complexity, articulation is likely to occur in stages. Dornsife (1992) points out that most schools begin by articulating similar, existing courses. Articulating courses means that the competencies addressed in selected postsecondary courses are compared with competencies of similar courses offered at the secondary level (e.g., keyboarding, drafting, computer fundamentals) to see if advance credit is appropriate or if there is unnecessary duplication in the courses. Eliminating duplication can either shorten the student's program of study or allow the student to reach a more advanced level before graduation. Dornsife provides examples of this stage of articulation and describes both its strengths and weaknesses (1992, p. 39-41).

The second stage of articulation (modification of courses and course sequences) and the third stage (developing completely new courses and course sequences) will be required if the goal of articulation cited at the beginning of this chapter is to be reached. That goal is "the creation of an educational system without artificial divisions, so that the whole educational period becomes one unbroken flow. . . ." The Indiana Tech Prep Model clearly anticipates such a goal, and every effort should be made to achieve it.

REFERENCES

Belcher, C. (1991). Smoothing the rough spots. In D. Hull & D. Parnell (Eds.), Tech Prep associate degree: A win/win experience (pp. 115-149). Waco, TX: Center for Occupational Research and Development.

Dornsife, C. (1992). Beyond articulation: The development of Tech Prep programs (MDS-311). Berkeley: University of California, National Center for Research in Vocational Education.

Padden, H. (1991). 2+2+2 equals college credit in California. In D. Hull & D. Parnell (Eds.), Tech Prep associate degree: A win/win experience (pp. 179-189). Waco, TX: Center for Occupational Research and Development.

Stein, J. (Ed.). (1975). The Random House college dictionary (Rev. Ed.). New York: Random House.

CHAPTER 6

SMOOTHING THE ROUGH SPOTS

by
J. Dudley Herron
Professor of Science Education
Department of Curriculum and Instruction
Purdue University

Abstract

An elaboration of a few issues discussed in the Hull and Parnell (1991) chapter by the same title, focusing on potential problems that must be addressed as Tech Prep is implemented in Indiana. This chapter will be of primary interest to Tech Prep regional coordinators and other leaders in Tech Prep implementation, and it should be treated as a supplement to the chapter in Hull and Parnell (1991).

Indiana Tech Prep Training Materials: Division I
Sponsored by:
The Indiana Department of Education
Project # 92S-4762

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

SMOOTHING THE ROUGH SPOTS

Introduction

Throughout these materials impediments to Tech Prep implementation have been identified and suggestions have been given for overcoming them. Most of the important issues are addressed by Belcher in Hull & Parnell (1991, pp. 115-149), and that discussion will not be repeated here. Only those issues that seem to be of particular concern in Indiana and have not been addressed elsewhere are discussed in the following sections.

Teacher Concerns

Teachers are concerned about possible loss of jobs, the need to change what they are doing, and the quality of the program advocated by Tech Prep. In one of Indiana's demonstration sites participation by English teachers has been limited because teachers felt that the language arts proposed for Tech Prep did not include enough literature. In another demonstration site the science faculty argued that their existing courses met the needs of Tech Prep students better than the applied courses that were proposed. Teachers in another school were annoyed that the computer equipment that was purchased for Tech Prep was placed in an area other than their own. In one school the administrator in charge of implementation was viewed as heavy handed. Petty as such concerns may sound, they will mean the difference between success and failure of a Tech Prep program.

Tech Prep coordinators should listen carefully to teacher concerns. If the head of the math department insists that existing courses are meeting the needs of Tech Prep students, check it out before pushing for change. Do students targeted for Tech Prep take algebra and geometry now? If so, how well are they doing? If the math faculty can show that potential Tech Prep students are achieving the math competencies advocated for Tech Prep, energy should not be wasted on trying to fix what is not broken. However, if this is not the case, then the math faculty must be encouraged to propose steps that can be taken to improve the math skills of average and below average students. Similarly, if science teachers insist that applied courses are not needed for Tech Prep students, see how well students are able to apply science concepts outside of the science classroom. If they do well, leave the science faculty alone; if they do not, encourage the science faculty to work with you to develop courses that will enable Tech Prep students to apply science in meaningful contexts.

The key to meeting teacher concerns is to take those concerns seriously and collect data pertaining to them. If the data support the teacher concerns, deal with the concerns accordingly. If the data do not support the teacher concerns, then ask the teacher to reconsider his or her position.

Administrator Concerns

Administrators are concerned about the cost of Tech Prep, the need to add new classes, and the need to add new staff. They know that interdisciplinary instruction requires that teachers have common planning periods, and they know that makes scheduling difficult. Administrators wonder whether the additional computers requested for Tech Prep are really needed. If the computers are needed, administrators wonder how they will find the money to buy them. While all of these concerns are real, some are over stated.

Issues related to the cost of Tech Prep are discussed in Chapter 2 under **Identifying and Securing Resources** (pp. 6-8). The reader should refer to that discussion for suggestions for securing additional resources. Although full implementation of Tech Prep *will* require some reallocation of resources, actual costs are likely to be less than many administrators have envisioned. There should be no need for additional staff, for example. As pointed out in the section on **Curriculum Development** in Chapter 3 (pp. 8-9), courses added for Tech Prep should replace courses that are currently being taught. The total number of courses taught should go down rather than up, and the number of staff should remain the same.

Scheduling is an issue that must be addressed. How it is addressed will depend on factors such as school size and ability of teachers to meet outside of the school day. In addressing this problem, administrators should not assume that provision of a common planning period throughout the school year is the only alternative. Daily meetings between cooperating teachers are usually unnecessary. Providing a block of time once or twice each month will meet most planning needs. Initial planning, which is likely to require more time, may be made possible by hiring substitutes in order to release key teachers for planning.

2+2, 4+2, 2+2+2, or 4+2+2

In The Neglected Majority Dale Parnell described Tech Prep as a 2+2 program; i.e., a program of study involving the last two years of secondary school plus two years of postsecondary education. Since that book provided the model for Indiana's P.L. 217, Tech Prep is normally conceived as a 2+2 program in Indiana. However, the Monroe County (Bloomington) Demonstration Site elected to begin its Tech Prep program in grade nine. Thus, its Tech Prep program is more appropriately described as a 4+2 program. According to Belcher, North Carolina "determined that, in order for the desired academic skills to be achieved, a 4+2 model . . . was needed" (Belcher, 1991, p. 128). Others have developed Tech Prep programs that articulate with four-year degree programs. Such programs are referred to as 2+2+2 or 4+2+2, depending on whether two or four years of secondary schooling is incorporated in the program. According to Don Gentry, Dean of the School of Technology at Purdue University, demand is very high for graduates of four-year programs in technology. Based on this demand, Fred Emshousen, Associate Dean of the School of Technology at Purdue and Director of Purdue's Statewide Technology program has committed Purdue Statewide Technology to 2+2+2 or 4+2+2 programs for Tech Prep.

Even with strong encouragement for students to continue their education beyond the secondary school, some students will not be convinced. They will terminate their education (at least temporarily) after high school graduation. Many of those who continue their education in an associate degree program will do so with no intention of going beyond that level. The more that Tech Prep programs can be designed so that students can leave after high school with marketable skills or to continue through an associate or bachelor's degree program to strengthen those skills, the better the program will meets Indiana's needs.

Student Ability Levels

Some Indiana educators have expressed concern that P.L. 19 mentions Tech Prep and college prep "tracks," but no general or vocational "tracks." Implicit in such expressions of concern is the belief that many students are not capable of completing either a college prep or Tech Prep curriculum.

In spite of evidence to the contrary, there are strong beliefs among education professionals that a substantial fraction of students lack the *intellectual capacity* to learn more than the simplest ideas about mathematics and science. Such beliefs lead to low expectations of students and those expectations become self-fulfilling prophesies. This state and nation can not allow education to operate on such assumptions. The economic price society pays for education that is inadequate to earn a living wage is far too high.

Saying that all students can learn does not make it so, and teachers are keenly aware of differences in aptitude among their students. The evidence for differences in intellectual aptitude is too strong to ignore, and it is does not help Tech Prep to adopt untenable positions. It does help to understand intellectual aptitude in terms of *learning rate* rather than *learning capacity*.

The idea of intellectual aptitude as a measure of the *rate* at which a person is able to learn rather than a measure of the *capacity* for learning was proposed by John Carroll (1963) and popularized by Benjamin Bloom (1971). Carroll's model acknowledges that some students will take longer to master material, so it may be necessary to organize courses such as algebra, geometry, and physical science so that students can study them for longer than the traditional time span. If students have progressed through the first eight to ten years of schooling under a fixed time model, it is likely that students with lower intellectual aptitude have not mastered some concepts and skills that are prerequisite to the mathematics and science being taught. Opportunities to remediate deficiencies *without lowering final expectations* may be required as well.

As schools implement Tech Prep it is appropriate to acknowledge that students differ in intellectual aptitude and learning style. The Tech Prep curriculum must be developed to accommodate those differences. However if "general education" means a program that satisfies graduation requirements through unchallenging courses in an unfocused plan of study, and if "vocational education" means courses that do not provide the skills required for current and future jobs, such options should not be continued once Tech Prep has been implemented. The clear intent of P.L. 217 and P.L. 19 is to provide *all* students with an education that prepares them for gainful employment in a highly competitive, global economy. Programs of study that do less than that do not meet the legislative intent.

Students differ in the *way* they learn as well as in the *rate* at which they learn. Although it is popular to talk about differences in learning styles, little can be said other than to acknowledge that such differences exist and to urge teachers to provide a variety of learning opportunities that will appeal to students with different learning styles.

Staff Development

The purpose of this manual is to assist in local and regional staff development for Tech Prep. However, as Belcher points out, "[m]ost of staff development activities will be determined by what the people involved already know and what they need to know" (Belcher, 1991, p. 135). It is important that local Tech Prep leaders neither feel compelled to address every issue treated in this manual nor feel constrained to limit staff development to the topics included.

An important component of staff development will be establishing a climate where teachers feel comfortable admitting what they do not know. As workplace applications are introduced in academic courses, academic teachers will encounter equipment that they have never seen and do not know how to use. As the curriculum becomes more interdisciplinary, teachers of all stripes will find that they lack knowledge for competencies that they are expected to teach. Teachers must understand from the beginning that they can expect to encounter areas of ignorance, and they must know that help will be available to fill their knowledge gaps if they ask.

REFERENCES

Belcher, C. (1991). Smoothing the rough spots. In D. Hull & D. Parnell (Eds.), Tech Prep associate degree: A win/win experience (pp. 115-149). Waco, TX: Center for Occupational Research and Development.

Bloom, B. (1971) Mastery learning. In J. W. Block (Ed.). Mastery learning: Theory and practice. New York: Holt, Rinehart & Winston.

Carroll, J. (1963). A model of school learning, Teachers College Record, 64, 723-733.

CHAPTER 7

ECONOMIC EDUCATION FOR TECH PREP

by
Peter Harrington
Indiana Council for Economic Education
Purdue University

Abstract

The Indiana Tech Prep Model calls for students to demonstrate competencies in applying economic principles. This chapter describes ways that the Indiana Council for Economic Education can assist schools in meeting that goal.

Indiana Tech Prep Training Manual: Division I
Sponsored by:
The Indiana Department of Education
Project # 92S-4762

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

ECONOMIC EDUCATION FOR TECH PREP

Introduction

The Indiana Tech Prep Model includes two core competencies that receive little attention in Hull and Parnell (1991). Those competencies are:

> **Economics** - demonstrate competencies in applying economic principles
> **Introduction to Careers** - demonstrate an awareness of careers and an ability to examine current and evolving technical careers

Understandably, demonstration sites have devoted less attention to economics than to science, mathematics, and language arts. Consequently, the curriculum materials developed at the five demonstration sites provide less guidance for including economics in a Tech Prep program than for including other subjects. Fortunately, there is an organization operating in Indiana that can provide assistance in this area. It is the Indiana Council for Economic Education (ICEE), a not-for-profit education agency based at Purdue University.

Background on ICEE

The ICEE and its affiliated ten regional university centers, in cooperation with the Indiana Department of Education, have made a long-range commitment in preparing Indiana's youth for the 21st Century workplace. The network can assist the five (5) Demonstration Sites and fourteen (14) Regional Consortia in the following manner:

- Training secondary teachers in basic economics via intensive summer workshops and regional awareness programs
- Providing teachers with quality "how to" classroom materials
- Testing students for their proficiency in economics
- Developing and distributing quality student materials to the schools
- Assisting school corporations in curriculum planning, development and evaluation, particularly as it relates to technology and the career and economics core of the Tech Prep Curriculum

Need for Economic Education in Tech Prep

The workplace and family environment have changed dramatically in the past ten years. And with the growth of technology, information, and global competition, all students leaving school should have a basic understanding of economics and have the problem-solving, critical thinking, communication and teamwork skills necessary to survive and prosper as workers, consumers, and citizens now and into the 21st Century. The student's well-being and the future of Indiana are at stake.

An Economic Education/Workplace Literacy Program

Choices and Changes, a program for grade 3-9, has been successfully piloted and refined in the Indianapolis Public Schools these past four years. This program examines career opportunities, required skills, attitudes towards work, and other factors crucial to becoming productive in the work force. The program has been introduced into the Elkhart, Mishawaka, Muncie, South Bend, and Warsaw Community Schools during the 1991-92 school year.

Choices and Changes is a unique, student-centered program aimed at helping all students realize their full potential. It helps young people:

- Realize that they have the ability to make a change in their lives through the "choices they make"
- Believe they are valuable and learn to "invest in themselves" by developing their skills and knowledge; and
- Realize that "they are part of the economy" and that their decisions will help "shape their future roles" in the economy

Choices and Changes is different from other programs because it:

- Introduces children to vital concepts at an early age
- Assures lasting impact by reinforcing program themes at four key grade levels
- Clarifies the link between effort, performance, and rewards
- Combines economic content with everyday decision-making
- Demonstrates the importance of self investment in order to participate in the economic system
- Recognizes the unique feelings and attitudes of children
- Provides substantive training and ongoing support for teachers
- Developed and field tested by teams of teachers and professional educators; and
- Can be integrated into the existing school curriculum, including Tech Prep.

Choices and Changes was clearly not designed for Tech Prep, but there is considerable overlap in the goals of the two programs. Choices and Changes could be refined to provide starting materials to meet the objectives of the Tech Prep curriculum. (See Attachment 2 for a description of this program.)

FACT SHEET
INDIANA COUNCIL FOR ECONOMIC EDUCATION

WHAT IT IS.

The Indiana Council for Economic Education (ICEE) is an independent, nonpartisan organization founded in 1954 to provide the public with a clearer understanding of basic economics through specialized educational programs. Its goal: to ensure that Indiana's citizens are better able to make decisions—career decisions, voting decisions, business decisions, and day-to-day household decisions—in a local, national, and international environment with complexities shaped in large part by basic economic forces.

HOW IT ACHIEVES ITS GOAL.

The ICEE, an affiliate of the national Joint Council on Economic Education, is headquartered at Purdue University's Krannert Graduate School of Management. The heart of its delivery system is a network of 10 university centers and a system of cooperating school districts spreading across the state. Its purpose is to provide teachers—kindergarten through college—with the training and materials necessary to educate Indiana's students in the fundamentals of economics, the American economic system and current economic issues. Programs for other opinion leaders—the clergy, reporters, employee groups, etc.—are also offered each year.

KEY ICEE PROGRAMS.

To name just a few of the Council's activities during the past year:

- Over 2,000 teachers participated in 80 workshops dealing with economics in the classroom.
- Over 100,000 students viewed the award-winning "Trade-offs," "Give and Take," and "Tax Whys" film series which present dramatic illustrations of real life economic problems.
- 106 school corporations received materials, teacher training and assistance in curriculum development.

THOSE WHO MAKE IT POSSIBLE.

The ICEE receives funding and advisory support from the major sectors of the economy—business, labor, agriculture, government, and education. Over 400 private sector contributors provide funds to cover program expenses. Each dollar received from the private sector is matched by more than $2 from public universities and from the Indiana Department of Education. These funds provide the personnel and institutional support required to deliver programs to thousands of Hoosier citizens each year.

IS THE ICEE ACCOMPLISHING WHAT IT SET OUT TO DO?

The ICEE is a program-oriented organization, and it has excellent results to share. For further information on ICEE, its programs and results, please contact:

Peter V. Harrington, Director
Indiana Council for Economic Education
Krannert Graduate School of Management
Purdue University
West Lafayette, Indiana 47907
Phone: (317) 494-8545

icee
INDIANA
COUNCIL
FOR
ECONOMIC
EDUCATION

CHOICES & CHANGES

Curriculum Summary

The materials for CHOICES & CHANGES are produced for four grade levels from primary through junior high. The themes, developed in age-appropriate ways for each level, are:

1. **Human Capital:** By investing in your own skills and knowledge, you can contribute.
2. **Decision-Making:** By making sound decisions, you can have more control over your life.
3. **Participation in the Economy:** By understanding your role in the economy, you can participate more productively.

The **Elementary I** unit (grades 2-4) focuses on broadening the children's concept of work and introduces them to human capital. They learn the importance of human capital in setting and achieving one's goals by studying workers in the marketplace. They are taught that they are already workers, and that their success is dependent on skills, just as the workers they interview need skills for their successes. They also learn a special skill that they can teach to someone else, thus applying their own human capital in helping others.

In **Elementary II**, students (grades 4-6) are taught that their ideas have value and that decisions based on these ideas can lead to productive and rewarding achievements. By studying inventors and their inventions and by using brainstorming techniques, students create their own inventions. They then produce and market a class-made item. Students learn the importance of creativity, initiative, perseverance, knowledge, and skills for reaching goals.

Junior High I students (grades 6-8) are taught the process of rational choice-making in their everyday real life situations. By applying economic concepts of scarcity, cost-benefit analysis and human capital development to situations with which they are familiar, students learn to make careful, reasoned decisions. They learn that they have the ability to take control of their lives, that a great deal of satisfaction comes from doing so, that their decisions affect others, and that choices of others affect them.

Junior High II students (grades 8-9) are taught to recognize that their behavior, as well as the behavior of others, is the result of choices, not chance. By studying how incentives and disincentives affect human behavior, they begin to understand that knowledge of the decision-making process assists one in predicting behavior. They learn that an investment in capital resources and in human capital leads to increased productivity, and that by developing their own knowledge, reasoning skills, and confidence, they can take responsibility for their own future.

This CHOICES & CHANGES Sample Kit contains the Unit Rationale, Summary of lesson content and teaching procedures, and one complete day's activity for each of the four grade levels.

ELEMENTARY I Grades 2-4

Lesson Content & Teaching Procedures

Lesson/Activity	Content	Procedures
Lesson 1 **I Am A Worker**		
Day 1 The Work I Do	The nature of work and why people work	Studying pictures of workers and identifying selves as workers
Day 2 Workers Make Goods and Provide Services	The nature of goods and services and what workers do to make/provide them	Reading and discussion to identify kinds of workers, goods, and services
Day 3 Workers Use Capital Resources	How capital resources help workers do jobs	A valentine-making project to understand the value of using capital resources
Day 4 Workers Use Human Resources	The nature of human resources, especially knowledge and skills	Observing a typing demonstration to learn the importance of human resources
Day 5 Workers On Their Jobs	Workers producing goods and services and cooperating in getting tasks done	Students observing workers on a field trip
Lesson 2 **I Can Improve My Human Resources**		
Day 1 I Can Use My Human Resources to Make a Good	Combining human and capital resources to produce a good	Making a hexaflexagon and improving it
Day 2 I Can Improve My Human Resources with Practice	Identifying ways to improve skills and measuring skill improvement	Students improve their hexaflexagons through practice
Day 3 Teaching Others Builds Human Resources	Improving planning and communication skills by teaching others	Students teaching younger students to make hexaflexagons
Day 4 I Make Choices, and I Have Alternatives	The nature of scarcity and recognizing choices are possible because alternatives exist	Using situations on choice cards and identifying alternatives
Day 5 Choices Have Consequences	Considering alternatives and their consequences	Small group task in identifying consequences of alternatives

ELEMENTARY II Grades 4-6

Lesson Content & Teaching Procedures

Lesson/Activity	Content	Procedures
Lesson 1 Creativity and Invention		
Day 1 I Can Be An Inventor	The nature of economic resources and their uses in producing a product	Brainstorming; individual task; and class discussion
Day 2 People Want New Things	The nature of human wants and the concept of market; how George Washington Carver did research to create new uses for the peanut	Student reading and class market survey
Day 3 I Can Create Something Valuable	The difference between an invention and an innovation; the meaning of (economic) value	Class discussion and student creativity task
Day 4 Traits for Success	The qualities of an inventor or innovator	Individual task on innovation; class discussion on what to produce
Day 5 Setting Goals	Deciding what to produce based on criteria and an established goal	Class discussion and group decision making on what to produce
Lesson 2 Producing a Product		
Day 1 Will a Good Idea Sell?	How a market survey can help determine product demand	Student reading and development of a market survey
Day 2 Success Requires Effort	The importance of finding out whether a product will be bought	Paired student interviews and actual survey conducted
Day 3 The Basics: What? How Many? and How to Produce?	Analysis of market survey results; answering the what, how many, and how to produce questions	Continued student analysis of survey results and making production decisions

JUNIOR HIGH I Grades 6-8

Lesson Content & Teaching Procedures

Lesson/Activity	Content	Procedures
Lesson 1 **The Economy and My Place In It**		
Day 1 What is an Economy?	The nature of an economy and the rules of exchange	Small group planning, an auction, and debriefing
Day 2 Goods, Services, and Work in the Economy	The categories of goods and services; roles of consumers and workers in an economy	Classifying goods and services using index cards; discussing observable and "backstage" economic activity
Day 3 People Use Their Human Capital in the Economy	The nature of human capital and how it can be improved	Performing individual and cooperative tasks using one's own human capital
Day 4 I Am Part of the Economy	Participation in the economy and the nature of choice-making	Using a time line to identify human capital contributions and consumer choices
Day 5 Making Economic Choices	Wants, scarcity, choice-making, and opportunity cost	Students read and work through a scarcity problem
Lesson 2 **Making Choices**		
Day 1 My Choices Are Based on My Values	Human values and their influence on choice-making	Participating in a "what if" series of choice-making situations
Day 2 Choices Have Costs and Benefits	Choice-making and the identification of the costs/benefits of each choice	Playing a classroom version of *Let's Make a Deal*
Day 3 Ways to Make Choices	Alternatives for choice making and differing results	Small group task on ways to make choices
Day 4 My Choices Affect Others	A choice and the subsequent chain of events which affect others	Student learning game on choices and their results
Day 5 Choices Make a Difference: Worker Interviews	Choices adults have made and the effects on their lives	Interviewing adults about work (career) and consumer choices

JUNIOR HIGH II Grades 8-9

Lesson Content & Teaching Procedures

Lesson/Activity	Content	Procedures
Lesson 1 Making Choices		
Day 1 I Make Choices	The nature of scarcity, identifying alternatives, and recognizing opportunity cost	Class discussion, individual task, reading
Day 2 Identifying and Choosing Among Alternatives	Identifying alternatives in a choice situation and considering costs/benefits of each alternative	Small group task and class discussion
Day 3 Choices: Costs and Benefits	Cost/benefit analysis and the need for compromise	Role-play and large group discussion
Day 4 What Influences Choices?	Incentives that encourage choices and disincentives that discourage choices	Personal reflection, sharing own views in small group
Day 5 Which Job Would You Choose?	The predictability of behavior if incentives/disincentives are known	Individual choice-making, small group analysis of choices
Lesson 2 Human Capital and Productivity		
Day 1 Changing Productivity	Inprovement of productivity based on improvement of human capital	Simulation of a production situation
Day 2 Human Capital and Productivity	Cooperation and use of capital resources can improve productivity	Individual and team production compared, use of videotape from Give & Take (optional)
Day 3 Thinking About My Human Capital	Nature of labor force and the connection between productivity and income	Self-assessment of skills and interests and class debriefing
Day 4 What Employers Want	Personal Qualities which influence hiring decisions	Student reading and job interview role-play
Day 5 The Want Ads: What Do They Really Mean?	The quality of human capital and its influence on hiring decisions	Analysis of want ad information and self-assessment of own skills

CHAPTER 8

TECH PREP AS SYSTEMIC SCHOOL REFORM

by

J. Dudley Herron
Professor of Science Education
Department of Curriculum and Instruction
Purdue University

Abstract

Chapter 8 discusses the relationship between Tech Prep and other school reform efforts. Specific reference is made to Indiana 2000 and Re: Learning. ASCD principles of school reform are presented to show that Tech Prep is consistent with accepted principles of reform. This chapter will be of primary interest to those who are concerned about the relationship of Tech Prep to other school reform efforts.

Indiana Tech Prep Training Materials: Division I
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

TECH PREP AS SYSTEMIC SCHOOL REFORM

In the Aftermath of A Nation at Risk

Current school reform, of which Tech Prep is a part, is usually said to have begun with publication of A Nation at Risk in 1983. Since then hundreds of committee reports and scholarly publications have detailed what is wrong with schools and how to fix them. Scores of programs have been launched with varying degrees of hype and financial support. Many efforts have already been abandoned as impractical or wrong-headed.

School administrators and teachers are understandably reluctant to participate in yet another futile effort to "save our schools." They are tired, angry, and confused. At a time when everybody claims to have the "right answer," why should they commit limited energy and resources to Tech Prep rather than one of the other school reform movements? How does Tech Prep relate to other efforts underway in Indiana? These are good questions that reveal legitimate concerns, and they are addressed here.

Indiana 2000 and Tech Prep

The 1991 Indiana General Assembly passed legislation to continue school restructuring in the state. Under this legislation, the school corporation may designate one or all schools within the district to be nominated as an Indiana 2000 school. Indiana 2000 is a designation meaning that the school is looking at long-term systemic change. It *does not* mean that there is a particular program to be implemented. To be considered for Indiana 2000 school designation, a school must demonstrate a) a commitment to restructuring; b) vision, including short and long term goals; c) a plan for professional development; d) a plan for ongoing student and program evaluation; e) a plan to address the national goals of America 2000; f) a strategy for achieving the national goals; and the school must agree to certain administrative conditions.

Becoming an Indiana 2000 school represents a commitment that goes well beyond the requirements of Tech Prep, but in no way does it interfere with the implementation of Tech Prep. In fact, it could help. Indiana 2000 schools will receive up to $25,000 for the same kind of planning and staff development that is required for Tech Prep implementation. Perhaps of even more significance, Indiana 2000 schools will be permitted to invoke a waiver of any rule adopted by the State Board, providing flexibility to carry out radical reform if that is desired. Although Indiana 2000 has a different origin and a more global emphasis, it is aimed at the same problems addressed by Tech Prep. The philosophical principles that undergird Tech Prep are the same principles that influence Indiana 2000 and most other systemic reform efforts.

Re:Learning and Tech Prep

Re:Learning is another systemic school reform in which Indiana schools participate. This effort unites the Coalition of Essential Schools with the Education Commission of the States to work with people in all parts of the education system to redesign the total school system. (Tech Prep does not require redesign of the *total* school system, but it clearly involves a good part of it.) It is grounded in the belief that school redesign efforts must focus on the primary purpose of schooling--to help all students learn to use their minds well (a goal shared by Tech Prep)--and must include the total education system from schoolhouse to statehouse. *Re:Learning* has no finished models of the perfect redesigned system (nor does Tech Prep, though it does have a state model which outlines general principles for the program). Those must evolve from the hard work of committed students, teachers, administrators, policy makers, and community members (the same people who are called upon to design and implement Tech Prep). *Re:Learning* seeks to stimulate and support redesign work at the school, district, state, and national levels (just as there are local, regional, state, and national Tech Prep initiatives).

Re:Learning schools agree to work at adapting nine principles to their own unique situation. These principles focus on aspects of schools that are not addressed by Tech Prep, so they are not identical to the principles outlined in the Indiana Tech Prep model. However, the two sets of principles are compatible. The *Re:Learning* principles are:

1. **Intellectual focus.** The school should focus on helping students learn to use their minds well. It should not attempt to be "comprehensive" at the expense of its central intellectual purpose.
2. **Simple goals.** The school's goals should be simple: that each student master a limited number of essential skills and areas of knowledge.
3. **Universal goals.** The schools' goals should apply to all students, although the means to the goals will vary as those students themselves vary. School practice should be tailored to meet the needs of every group of students.
4. **Personalization.** Teaching and learning should be personalized to the maximum extent feasible. To that end, a goal of no more than 80 students per teacher should be vigorously pursued and decisions about curriculum, allocation of time, and choice of teaching materials and their presentation must rest unreservedly with the school's principal and staff.
5. **Student-as-worker.** The governing metaphor of the school should be student-as-worker, rather than the more traditional teacher-as-deliverer-of-instructional-services. A prominent pedagogy should be coaching, to provoke students to learn how to learn and thus how to teach themselves.
6. **Diploma by "exhibition."** The diploma should be awarded upon a successful final demonstration of mastery--an exhibition--of the central skills and knowledge of the school's program. The familiar progression through strict age grades and "credits earned" by "time spent" in class will be unnecessary.
7. **Tone.** The tone of the school should explicitly and self-consciously stress values of unanxious expectation ("I won't threaten you, but I expect much of you"), of trust (until abused) and of decency (fairness, generosity and tolerance). Parents should be treated as collaborators.
8. **Staff.** The principal and teachers should see themselves as generalists first (teachers and scholars in general education) and specialists second (experts in one particular discipline). Staff should expect multiple obligations (teacher-counselor-manager) and commitment to the entire school.
9. **Budget.** Ultimate administrative and budget targets should include a total student load of 80 or fewer per teacher, substantial time for collective staff planning, competitive staff salaries and a per-pupil cost no more than 10% above that of traditional schools. Inevitably, this will require the phased reduction of some services provided in many comprehensive secondary schools.

SREB and Tech Prep

Strictly speaking, the reform movement sponsored by the Southern Regional Education Board (SREB) is separate from the Tech Prep movement. However, its focus and philosophical underpinning is so close to that of Tech Prep that it is often treated as a part of the Tech Prep reform effort. The similarity is so close that elsewhere in this document we refer to an SREB report and to results from SREB pilot sites as part of Tech Prep.

Other school reform

There are other systemic school reform efforts; some national, some state, and some local. SIRIUS-A: Navigating by the Stars (Reigeluth, Norris, & Ryan, 1991), a project funded by the Center for School Improvement and Performance, Indiana Department of Education, and conducted by the School Restructuring Consortium, School of Education, Indiana University, conducted a national survey which identified sixty schools that had initiated systemic restructuring. Twenty of these schools were studied in detail, and " 16 in-depth case studies were written on what were determined to be good examples of systemic redesign (p. 2)." The three SIRIUS-A reports (*Executive Summary*, *Synthesis of the Process and the Features*, and *Cases*) provide a good overview of school reform efforts.

Getting involved in another systemic reform efforts could provide resources and leadership that could enhance the planning and implementation of Tech Prep, but it is difficult to see how such involvement could interfere with Tech Prep goals. All of these reform efforts grow out of the same concerns about our society and the ability of schools to address social needs. They are based on the same educational research and similar philosophical considerations. Some (such as Tech Prep) focus on only one aspect of the problem while others (such as *Re:Learning* and *Indiana 2000*) are more comprehensive, but they are not in conflict.

ASCD and Tech Prep

The Association for Supervision and Curriculum Development (ASCD) is a highly respected professional organization devoted to school improvement. The ASCD Curriculum Handbook (1991) is a valuable resource for anyone engaged in curriculum reform. The handbook currently contains sections on curriculum, language arts, mathematics, science, and social studies. Sections currently under development with anticipated dates are: Foreign Languages, September 1992; Visual and Performing Arts, January 1993; Health and Physical Education, September 1993; Vocational and Technical Education, January 1994. The handbook also contains case studies of local curriculum reform efforts; articles on topical issues such as drug abuse prevention, multicultural education, technology integration, and constructivism; and extensive lists of resources that can be used to assist in curriculum reform. Newsletters, a reference diskette, and online assistance from ASCD's telecommunications service provide means to keep the handbook current.

The attached article is taken from the ASCD Curriculum Handbook (1991, pp. 2.29-2.34) and is reprinted by permission. It outlines the principles that ASCD argues should guide all curriculum renewal efforts, and we include it without change to show that reform advocated by the Indiana Tech Prep Model is guided by the same principles that guide school reform in general. Tech Prep is not a carelessly developed "quick fix" or the product of some legislative whim. Rather, it is a thoughtfully developed model for school reform that is in the mainstream of current thinking about what needs to be done about schools to make them more effective.

References

ASCD Curriculum Handbook. (1991). Association for Supervision and Curriculum Development, 1250 N. Pitt Street, Alexandria, Virginia 22314-1403.

Reigeluth, C. M., Norris, C. A., & Ryan, D. F. (July, 1991). SIRIUS-A: Navigating by the stars: Report I: Executive summary. Bloomington, IN: Indiana University, School Restructuring Consortium, School of Education.

Principles Guiding Futures Planning for Curriculum Renewal

Gordon Cawelti

612-91033

The continuing push for school improvement over the past decade has brought greater attention to several fundamental flaws in the typical school curriculum. Instructional leaders restructuring their programs for the future must develop strategies to address these deficiencies. The most significant measures of the success of particular instructional programs are not test scores, but how well a school's graduates subsequently succeed in their personal and work lives. Using this as a measure, it is clear that substantial changes in the school curriculum are required to better prepare students to succeed in the 21st century.

After years as a world leader, the United States has lost its competitive position in international trade, evidenced by the increasing trade deficit of recent years. Further, while this country provides perhaps the highest standard of living in the world for most citizens, increasing numbers of people, including children, are living well below the poverty level. Poverty brings with it all the attendant problems of poor health, insufficient care for the aged, crime, drugs, and inadequate schools. Many urban areas are decaying, and state governments are increasingly finding themselves financially unable to provide the services their citizens desperately need. A deteriorating family structure complicates the responsibilities of schools, as does the steady flow of immigrants seeking a better way of life in this country.

Maintaining a prosperous economy and a high quality of life for all citizens is closely linked to the task of education. In the midst of increasing economic pressure and social ills, evidence has continued to mount that too many students drop out of school or are unable to perform at a reasonable standard of proficiency on tests of basic communication or problem-solving skills, much less demonstrate high-level understanding of important concepts in subject areas such as science (Mullis and Jenkins 1988). In times of economic stress, there is a tendency at the federal level for education to be viewed as an instrument of national policy, with a concomitant increase in interest in a core curriculum and national standards of performance (Skilbeck 1990). The increasing prominence of these issues on the national agenda is testimony that the United States is currently following the trends already well established in Japan, England and Wales, Canada, France, and Germany.

Gordon Cawelti is the Executive Director of the Association for Supervision and Curriculum Development, Alexandria, Virginia.

Schools obviously cannot be held responsible for all the ills of society, but the flaws in our economic, social, and educational systems clearly do suggest the need for a fundamental re-examination of both the appropriateness and effectiveness of the traditional school curriculum. Society desperately needs both a better trained workforce and citizens whose personal lives are productive and satisfying. All societies use their schools to transmit their culture or heritage. In our society, schooling has become the primary vehicle to enhance the quality of life and to improve conditions for the generations that follow. Thus, the curriculum deliberations and planning of today's school leaders ought not to focus only on how bad or good schools are today, but rather on whether or not the instructional programs provided to all students represent the most appropriate learning experiences that can be designed to serve the future needs of today's students.

The mission of ASCD's Curriculum/Technology Resource Center is to help school leaders respond aggressively to the challenge of meeting the future needs of students. This handbook is intended to provide an authoritative source of information from which to craft an effective response.

For almost a decade, ASCD has worked to sort out the curriculum issues faced by schools attempting to redesign their programs for the future. Several consortiums of schools from around the world have brought together teams of teachers, principals, board members, and central office leaders for two-year programs to consider the consequences of rapid social change and the implications of new advances in teaching and technology for their schools' curriculums. They have deliberated the effects of changing family patterns (for example, the large numbers of children coming from single-parent and poor families), the shift from an agricultural/industrial to an information/service society, and the interdependence of American society and other societies around the world. From these deliberations, as well as studies, analyses, and extrapolations, leaders of elementary, middle grades, and high schools have identified several principles that are useful to guide planning for future curriculums.

What follows is a description of seven principles you can use to guide your decision making when restructuring your curriculum so that it serves the future needs of students, whose lives are so dependent on what today's education leaders decide.

Curriculum Principles

A Balanced Core

1. A *balanced core of common learning* ensures that all students are challenged with learning experiences judged most appropriate to their future lives.

Key elements of the core of common learning should be organized around fundamental themes addressing societal concerns, such as civic competence, world peace, the environment, and developing an international perspective that seeks to improve the quality of life for all societies around the world.

Balance is a key element of this principle. While improving basic skills is essential, it should not come at the expense of, for example, the arts and humanities. Therefore, the curriculum content must be more carefully selected and closely integrated. All schools need to become clearer in specifying what students must be able to know and do and in defining standards against which students' performances will be judged.

Teachers, in collaboration with subject area scholars, parents, and community members, should play a central role in selecting the most important common learnings for all students. They should be guided by the results of research, as well as their own experiences and that of their peers. In selecting content and defining the scope and sequence, they should adopt the overarching belief that in-depth study of a limited number of important topics will have a more lasting effect than a curriculum that tries to cover too many disconnected bits and pieces.

The curriculum must also become much more challenging than it has been for many students, to help push them to their full potential. Because students' lives will be increasingly affected by technology, the use of technology by students to facilitate learning must be integrated into the teaching and learning processes in every instructional area.

One of the responsibilities of the schools is to ensure that those issues that are most important to the human condition are reflected in the allocation of time and other resources in the schools. The concept of civic competence among future citizens ought to be one of the major societal concerns the curriculum seeks to permanently engender in students.

Results Oriented

2. The curriculum design *focuses on results, with multiple assessments of performances* closely related to the outcomes most appropriate to the future lives of students.

An authentic assessment program establishes multiple indicators of whether students meet high standards for what they are expected to be able to know and do. Multiple forms of assessments reduce reliance on the single, isolated behavior sampling found in standardized tests and relate outcomes more closely to real-world proficiencies. Dependence on the single, episodic, standardized test will be decreased as the information from such tests is supplemented with faculty members' judgments of individual student's work, which is continuously accumulated and maintained through the use of running records; portfolios; performances; and open-ended, criterion-referenced testing.

The use of authentic assessments, in addition to standardized tests, allows the primary emphasis of assessment to shift from short-term recall of frequently trivial facts to recognizing and encouraging student originality, insightfulness, and problem-solving capability, along with mastery of important information. Learning how to learn will equip students with the skills they need to understand changes and advances that continue to come at a rapid rate.

Interdisciplinary

3. The curriculum is organized on an *interdisciplinary* basis to ensure deeper understanding of complex phenomena and to make the "connectedness" of knowledge clear to students.

Each year the total body of knowledge increases. There are many topics (such as environmental education, drug abuse, population control, economic education, and multicultural education) that are important quality of life issues, but do not necessarily require a new course.

As issues and understandings become more complex, student learning will best be fostered by integrating important information from several subject fields through interdisciplinary instruction. Interdisciplinarity involves the integration of information into a conceptual whole. It is more than merely having two specialists teach in the same classroom or offering classes in consecutive time slots. Biomechanics is an interdisciplinary course, a biology/technology course sequence is not. True interdisciplinarity requires a fundamentally new frame of reference for organizing the content of the curriculum.

Active Learning

4. The curriculum is designed to ensure that students are *actively involved* in the learning process and increasingly assume responsibility for their own learning.

A key element of curriculum design is to translate the content into a varied and stimulating series of learning experiences or events that interest students and help them relate new content to previous knowledge and make connections between school experience and real-world issues. The traditional curriculum is a vestige of decades past when most students finishing pre-collegiate education were highly motivated and better able to handle abstractions than today's diverse school population. Rather than viewing students as passive recipients of information, today's most effective learning experiences require students to become actively engaged in questioning, discussing, relating, and thus, reformulating information into patterns that they can understand and use.

Diversity

5. Instructional materials, teaching strategies, and the school's culture *recognize and respect student diversity.*

One of the major weaknesses of traditional schools and curricular programs has been their slowness in adjusting to the presence of students who are different in terms of race, ethnicity, and religion, and to changing scholarly conceptions of culture. In part, this is attributable to over-dependence on textbooks and long cycles of curriculum review and renewal.

The principle of recognizing student diversity applies to all schools but has particular significance to those schools with high concentrations of students of non-Anglo origins. In schools that value diversity, instructional materials reflect it both symbolically (in the kinds of people and events depicted graphically) and substantively. Attention is given to the contributions of all major civilizations and individuals representing a variety of ethnic groups or religious affiliations, emphasizing those mirrored by the school population. Teaching strategies accommodate various learning dispositions, and the entire culture of the school reflects and respects diversity.

Education for All

6. The school organization *avoids tracking plans* that deny any student access to a substantive program of electives or general education.

Numerous studies of ability grouping have failed to demonstrate any virtue, other than ease of management. These studies, in fact, have shown that tracking dooms many students to mediocrity and low expectations. The assignment of students to particular levels should reflect the belief that all students can learn. The selection of curriculum content and learning experiences should be guided by the belief that subjects such as chemistry, algebra, literature, and history are useful to all students, and that all students can master key concepts through imaginative teaching. One interpretation of academic aptitude suggests that perceived differences in aptitude mean some students may take more time to demonstrate mastery, or that different explanations must be provided for some students, but no student need be denied the opportunity to acquire the knowledge and skills essential to succeed at a high level (Guskey,1986).

Thinking Curriculum

7. Classroom strategies have a strong focus on *developing thinking skills* in a systematic fashion that elevates the importance of critical thinking, problem solving, reasoning, and creative thinking over less complex intellectual tasks, such as recall of factual information.

The development of a "thinking curriculum" and the design of teaching strategies that give primary importance to how students are expected to be able to process new information are required. This means giving students more opportunities to ask questions, recognize that multiple perspectives are available on many topics, observe closely, classify and compare, infer, predict, and extrapolate. Assessment must be designed to serve instruction; in this case, to identify the extent to which so-called higher-order thought processes are used in the classroom. The development of thinking skills must be a primary goal in all curriculum designs so that future citizens will have "learned how to learn" and will continue to seek intellectual stimulation throughout their lives.

* * *

Implementation of these seven principles requires an effective strategic planning process. Long-term attention to inventing ways to apply these principles will do much to increase public confidence in the schools as well as to prepare all students for a better life in the 21st century. Some societies have long since abandoned support for public schooling, and only those parents with sufficient incomes are able to afford the kind of schooling all children deserve. We need both public and private schools that exist to nourish students' minds while preparing them for what everyone hopes will be a happy and productive life for every member of our society.

References

Guskey, T.R. and S. L Gates. (1986). "Synthesis of Research on the Effects of Mastey Learning in Elementry and Secondary Classrooms" *Educational Leadership*. 43, 8: 73-80.

Mullis, I.V.S., and L.B. Jenkins. (1988). *The Science Report Card*. Princeton, N.J.: Educational Testing Service.

Skilbeck, M. (1990). *Curriculum Reform: An Overview of Trends*. Paris, France: Organisation for Economic Cooperation and Development.

CHAPTER 9

EVALUATION OF TECH PREP PROGRAMS

By

James Greenan
Professor of Vocational Education
Department of Curriculum and Instruction
Purdue University

and
Fathi Jarwan
Research Assistant
Department of Curriculum and Instruction
Purdue University

Abstract

The CIPP program evaluation model is outlined, key evaluation questions are listed, and evaluation methods are described. Primarily of interest to those who are responsible for program evaluation

Indiana Tech Prep Training Manual: Division I
Sponsored by:
The Indiana Department of Education
Project # 92S-4762

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

EVALUATION OF TECH PREP PROGRAMS

The purpose of this article is to provide local leadership personnel with information useful in the design and conduct of Tech Prep program evaluations. The information is organized around definitions, rationale, purposes, evaluation models, evaluation questions, strategies and procedures, and evaluation plans. It is expected that the information described will be useful to personnel responsible in planning, implementing, and evaluating local and regional Tech Prep programs.

There are three main stages in the program development cycle. These three stages are (1) planning, (2) implementation, and (3) evaluation. Each phase has separate and distinct functions. None of these stages is completely discrete from the others. All three components must function together if the program is to effectively serve the target population. The program evaluation, whether connected to funding or legislative requirements or not, is essential and crucial to program success and continuity. The general purpose of program evaluation is to gather, analyze, and disseminate information that can be used to make informed decisions.

Program Evaluation Model

Over the past two decades several program evaluation models have been developed (Stufflebeam, 1985). These models were developed for a variety of contexts and evaluation purposes. However, one model, the Decision Making or CIPP Model, was developed especially for the purpose of evaluating educational programs. The CIPP model was developed and pioneered by Stufflebeam (1983). It has been adapted and used in a variety of educational programs including vocational and training programs (Wentling 1980). It also appears to be potentially useful for Tech Prep personnel for the evaluation of these programs.

The CIPP Model

It is very important to understand that evaluation is a process rather than a procedure or method. Evaluation is, therefore, ongoing. Program evaluation should be formative and summative. *Formative* evaluation is conducted continuously while the program is being implemented. It provides personnel with information useful to improve the program. *Summative* evaluation is conducted at the end of program and/or after the program ends (e.g., one year).

The CIPP model includes four components: (1) Context, (2) Input, (3) Process, and (4) Product. These components relate in very meaningful and practical ways.

Context Evaluation. Context evaluation is usually conducted when a program is being planned. Needs assessment is a common method to identify, define and describe the environment and its unmet (student and program) needs. The context evaluation also identifies the major constraints, issues, and problems related to the needs. Opportunities and resources are also identified in this phase. Ultimately, the program's mission, goals, and objectives are formulated during this evaluation phase. Of course, established programs should continue to reassess their needs and evaluate the appropriateness of their mission, goals, and objectives. This phase also assists the program evaluator to identify, delineate, and anticipate problems. It is important to note that program objectives are determined based on learner needs, society needs, and the nature of study materials. Objectives must also be tightly related to learning experiences and evaluation procedures. Therefore, local Tech Prep leadership committees should maintain adequate representation of all cooperating institutions and industry including subject matter experts and evaluation specialists. During this phase the major questions are: Where are we? What are our needs?, and Where are we going?

Input Evaluation. The major goal of an input evaluation is to identify the strengths of a program and the agencies in which it is administered, and to assess the ability of those agencies to achieve program goals and objectives. Alternative strategies and procedures to achieve the goal and objectives and overcome problems are also identified. For example, the personnel, facilities, resources, budget, time requirements, materials, and equipment necessary to implement the program are identified. Program plans are developed based on cost analysis (effects and benefits). Potential barriers are also identified. Evaluation data are gathered from all possible inputs for making program decisions. Input evaluation is typically done when planning new programs but should be done periodically throughout the program's life. The advocacy team technique is suggested (Stufflebeam, 1983) for conducting input evaluation especially in a situation where effective means to meet needs are not readily available. It may be applicable and useful to Tech Prep. The charge for this team of experts is to design a program proposal based on specific objectives for which a program is needed. The major question in input evaluation is: How will we get there?

Process Evaluation. The major purpose of process evaluation is to determine the adequacy, quality, and effect of a program relative to the program plan. Process evaluation is formative in that it is continuous. Process evaluation allows personnel to observe the program's operation and identify problems. Program areas in process evaluation include, but are not limited to, instructional effectiveness; staff communications; interpersonal relations; adequacy of resources, facilities, equipment, and materials; program philosophy; logistics; support services; and service for special needs populations. Summative evaluation activities are commonly done at the end of a program. The basic question in process evaluation is: How are we doing in getting there?

Product Evaluation. Product evaluation involves the determination of the adequacy, quality, and effect of a program outcome after the program has been completed. Evaluation is based on the program goal and objectives. Product evaluation results should relate to context, input, and process evaluation activities. Typical methods include tests, student follow-up, and employer follow-up surveys. The product evaluation identifies the intended and unintended and tangible or intangible products of a program. The major question posed in product evaluation is "Have we made it?"

Key Evaluation Questions

A very important phase of any program evaluation is formulating the key evaluation questions. The questions are generated from the goals and objectives of the program evaluation. For example, an objective in a Tech Prep evaluation may be to assess the effectiveness of a series of Tech Prep courses in a program. The key evaluation question may be, "What is the adequacy, quality, and effect of the applied technology courses?" Another question may be, "Are the support services provided to students adequate?" Further, "Are the materials, equipment, and facilities sufficient to deliver Tech Prep instructions." These and other key evaluation questions provide the basis for identifying the methods and procedures and data sources necessary to answer them. Instructors, administrators, students, parents, employers, program directors, and other personnel may all contribute in identifying the evaluation questions. Questions are also derived from the program plan and design.

Evaluation Methods

After personnel have identified the key evaluation questions, they may begin to select the methods and develop the procedures appropriate for collecting a variety of data and information. Instruments used to collect evaluation data and information may be formal and structured or informal and unstructured. Types of instruments include, but are not limited to:

> .Checklist - includes a list of statements with yes/no; always, sometimes, never kinds of responses.
>
> .Survey Questionnaire - instruments that include statements for which subjects respond by completing a scale (e.g. Likert Scale) or by providing open-ended comments.
>
> .Interview - a formal/structured or informal/unstructured method by which data are collected through interactive contact with the subjects: personal (face to face) interview, telephone interview.
>
> .Follow-up Survey Questionnaire - a summative evaluation technique utilized to collect data after subjects have completed a program. A variety of methods may be used: e.g., mail rating and/or open-ended scale, telephone interview, personal interview

These and other types of techniques are commonly used in context, input, process, and product evaluations. The selection of an appropriate method is based on the key evaluation questions, available data sources, time and resource constraints, and expertise of the evaluators.

The Evaluation Design and Plan

There are several components to a program evaluation design and plan. A design and plan should be well prepared to ensure that the evaluation is efficient, practical, and yields information that can be used by program planners and decision-makers to improve programs. The following components can serve as a guideline for preparing an evaluation design and plan.

A. Setting the Stage. This preliminary phase involves (1) defining the program to be evaluated, (2) identifying the client and audiences, (3) identifying the purpose(s) of the evaluation, (4) making a decision about the type(s) of evaluation needed, and (5) setting evaluation standards. From the outset the evaluator (or evaluation committee) and the client need to address these points and agree on a frame of reference for each point. With respect to the last point, it is useful to note that sound evaluation of educational programs should meet a widely accepted set of standards. Thirty standards have been developed by The Joint

Committee on Standards for Educational Evaluation (1981) representing both technically-oriented groups and practitioner-oriented groups. These standards were grouped in four categories: utility, feasibility, propriety, and accuracy of evaluation.

B. Collecting Information. Comprehensive evaluations require gathering information in five major areas:

1. Initial- and Post-Performance of learners Information about learner performance before, during, and after program implementation is required to determine whether the intended objectives have been attained, and to what extent. Appropriate methods for collecting this kind of information include institutional records, biographies, written tests, self-reports, rating scales, checklists, and follow-up surveys. A self-rating instrument including some major topics in training Tech Prep teachers is given as an example (Attachment 1). The instrument can be used for pre- and post assessments of trainees. Statistical methods including descriptive and inferential methods can be used to analyze responses and determine the significance of differences on each item and on the whole instrument. Comparing performance of Tech Prep teachers or students before and after training or instruction, or relating their performance to performance of some other control groups (not exposed to Tech Prep training or instruction) are typical and more convincing procedures for the study of change in learner's performance.

3. Program Execution To determine the extent to which a program has been carried out as intended and to identify deficiencies in program operation, process evaluation comes into play. Program evaluation has traditionally described program effectiveness in terms of program outcomes and products rather than program inputs or the process of instruction, but information about the actual implementation of a program is a critical part of program assessment. There are important evaluation questions that need to be answered in order to study and analyze the relationship between objectives, learning experiences, and assessment procedures. For instance, are learning experiences consistent with the stated objectives? Are the assessment procedures appropriate to learning experiences? Did the training or instructional program get started in time? Were necessary staff and materials available from the outset?

Wolf (1984) suggested three methods to gather information about the execution of a program, (1) observational procedures, (2) teacher reports, and (3) learners reports. Rating scales and checklists are often used to record observations. Observer comments may also be important as a supplementary source of information. Observational forms for recording observations are better developed with respect to specifics of the learning setting and objectives. Teacher records (e.g., lesson plans , logs) are another source of information about what happened in the learning setting. Locally developed descriptive scales with statements about instructional procedures and learning activities can be used by the learners to describe the learning situation. Teachers must be informed before introducing this procedure.

4. Costs The main question underlying the idea of program cost effectiveness is whether the same results could be achieved for less money using another approach or even using the same approach (Scriven, 1983). It may be a real challenge for the evaluation committee or leadership committee of Tech Prep to consider alternative strategies for meeting the objectives

stated for the Tech Prep program. Four categories are usually used in conducting cost estimations: time, space, equipment, and supplies. For decision making, the average cost per learner can be estimated for each approach or strategy, and comparisons can be made in light of attained benefits or objectives.

5. Indirect Impact and Attitudes This area includes two categories: (1) attitudes of involved groups, and (2) unintended products or outcomes. Views and opinions of individuals who are associated with the Tech Prep program in one way or another can be critical to program evaluation. Structured questionnaires, rating scales, and interviews are appropriate techniques for collecting attitudinal data from learners, instructors, administrators, parents, and industry personnel.

The second category covers both positive effects (e.g., desired learning not directly related to stated objectives) or negative effects (e.g., losing interest in taking more courses in a specific area after studying one hard course in the same area). Informal observation procedures and group discussions may be the most useful techniques for detecting negative effects of program.

References

Joint Committee on Standards for Educational Evaluation. (1981). Standards for evaluation of educational programs, projects, and materials. New York: McGraw Hill.

Scriven, M. , S. (1983). Evaluation ideologies. In G. F. Madaus, M. S. Scriven, & D. L. Stufflebeam (Eds.), Evaluation models: Viewpoints on educational and human services evaluation (pp. 229-260). Norwell, MA: Kluwer Academic Publishers.

Stufflebeam, D. L. (1983). The CIPP model for program evaluation. In G. F. Madaus, M. S. Scriven, & D. L. Stufflebeam (Eds), Evaluation models: Viewpoints on educational and human services evaluation (pp. 117-141). Norwell, MA: Kluwer Academic Publishers.

Wentling, T. L. (1980). Evaluating occupational education and training programs. Urbana, IL: Griffon Press.

Wolf, R. A. (1984). Evaluation in education: Foundations of competency assessment and program review (2nd ed.). New York: Praeger Publishers.

Tech Prep Training Program

Self-Rating Scale

Pre - Post Administration

Please rate your knowledge or skill level using the following scale:

1 = highly knowledgeable
2 = quite knowledgeable
3 = somewhat knowledgeable
4 = barely knowledgeable
5 = not knowledgeable at all

Knowledge/Skill Area	Scale				
1. Tech Prep philosophy and theory	5	4	3	2	1
2. Indiana tech prep model	5	4	3	2	1
3. Tech prep instructional strategies	5	4	3	2	1
4. Design a local needs assessment	5	4	3	2	1
5. Use IDEA net for communication	5	4	3	2	1
6. Subject matter integration	5	4	3	2	1
7. Program evaluation	5	4	3	2	1
8. Problem solving strategies	5	4	3	2	1
9. Cooperative vs competitive learning	5	4	3	2	1
10. Principles and mechanisms of change	5	4	3	2	1
11. Workplace literacy demands	5	4	3	2	1
12. Two-plus-two articulation	5	4	3	2	1
13. Interdisciplinary curriculum	5	4	3	2	1
14. Learning styles	5	4	3	2	1
15. Partnership with business and industry	5	4	3	2	1
16. Decision making skills	5	4	3	2	1
17. Competency-based instruction	5	4	3	2	1
18. Tech Prep marketing strategies	5	4	3	2	1
19. Team teaching	5	4	3	2	1
20. Group mechanisms and team building.	5	4	3	2	1

TECHPREP
INDIANA

TRAINING MANUAL
DIVISION II

Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

August 1992

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

Division II Table of Contents

Division II Table of Contents iii

Division II Overview

Abstract. Discusses preservice teacher education needs for Tech Prep and provides an introduction to the five instructional modules in Division II. Of primary interest to college and university teacher educators.

Introduction 3
What is different about Tech Prep 3
    Knowledge base for Tech Prep 3
    Student base for Tech Prep 3
    Instructional Organization for Tech Prep 3
    Teaching strategies for Tech Prep 4
Implications for preservice teacher education 4
    Teaching strategies 4
    Effect of specialization on teaching integrated subjects 5
    Levels of collaboration 6
Discussion of instructional modules 7
    What the modules have in common 7
    How the modules differ 7
    Who the modules are for 8
References 9

Module 1: Prototype Units in English/Language Arts

Unit 1: The Personal Job Search

Abstract. Illustrates instruction that incorporates applications based instruction, problem solving, cooperative learning, and other features of Tech Prep, but without requiring ongoing collaboration between two or more teachers. Shows how Tech Prep can be implemented in schools that are unable to establish collaboration across subject areas as a permanent part of the curriculum.

Introduction 3
Unit overview 3
General objectives 5
Instructional strategies 23
Lesson 1: Dream job writing assignment 25
Lesson 2: Occupational Cluster 26
Lesson 3: Data retrieval 27
Lesson 4: Job search 28
Lesson 5: Written communications 29
Lesson 6: Job applications 30
Lesson 7: Oral communication skills 31
Lesson 8: Interview etiquette 32
Lesson 9: Interview preparation 33
Lesson 10: Job interviews 34
Unit evaluation 35
Attachment 1: Cluster search methods 36

Unit 1 (cont.)

Attachment 2: Town & Country Homecenter job application 37
Attachment 3: R. R. Donnelley & Sons job application 39

Figures

Figure 1: Model for Goals, Proficiencies, and Objectives 4
Figure 2: A Three-Part Foundation 6
Figure 3: Five Competencies 7
Figure 4: Indiana Department of Education Language Arts Proficiencies . . 8
Figure 5: Personal Job Search Unit Objectives 9
Figure 6: Tech Prep Goals (Foundations) and Unit Objectives 10
Figure 7: Tech Prep Goals (Competencies) and Unit Objectives 14
Figure 8: Language Arts Proficiencies and Unit Objectives 18
Figure 9: Conceptual Framework for Personal Job Search 22
Figure 10: Unit Activities and Instructional Strategies 24

Unit 2: Create-A-Product

Abstract: *Illustrates instruction that involves collaboration between language arts and technology teachers. Units that involve collaboration with teachers of science, mathematics, or other disciplines could be developed along similar lines.*

Introduction 3
Unit overview 4
General objectives 4
Outline for unit content 15
Instructional strategies 16
Lesson 1: Group information and brainstorming 19
Lesson 2: Warmup for product design 20
Lesson 3: Company name, letterhead, and logo 21
Lesson 4: Product description 22
Lesson 5: Technical drawing of specifications and manufacturing steps . 23
Lesson 6: Market analysis 24
Lesson 7: Planning an advertising campaign 25
Lesson 8: Creating a magazine ad 26
Lesson 9: Producing the product 27
Lesson 10: Final presentation
Unit evaluation 28
Unit resources 29
Attachment 1: rules for group work 30
Attachment 2 Complete assignment sign-off form 31
Attachment 3: Personal shield 32
Attachment 4: Survey questions for group activities 33
Attachment 5: Product description 34
Attachment 6: Company name and letterhead 35
Attachment 7: Sample flow chart 36
Attachment 8: Sample cost sheet 37
Attachment 9: Market analysis 38
Attachment 10: Advertising campaign 39

Unit 2 (cont.)

Attachment 11: Library assignment 40
Attachment 12: Group evaluation questionnaire 42

Figures

Figure 1: Create-A-Product Unit Objectives 5
Figure 2: Tech Prep Goals (Foundations) and Unit Objectives 6
Figure 3: Tech Prep Goals (Competencies) and Unit Objectives 9
Figure 4: Language Arts Proficiencies and Unit Objectives 12
Figure 5: Conceptual Framework for Create-A-Product 15
Figure 6: Unit Activities and Instructional Strategies 17

Module 2: Prototype Units in Mathematics

Introductory comments for teachers

Abstract. Discusses relationship of prototype units to NCTM Standards and pedagogical issues such as use of calculators and grouping students for cooperative learning.

Background 3
Using the sample mathematics units in the classroom 3
Are the units of value to preservice teachers 4
Where do the units fit into the Tech Prep curriculum 4
Should students be given copies of each lesson 4
Can I adapt the units to fit the needs of my students 4
How do students react to these materials 5
How should students be grouped to do the activities in the lessons 5
Should students be allowed to use calculators 5
Why are most examples in these units in metric 5
Do I need to work with teachers from other subject areas 5
How do I take different learning styles into account 6
How do I assess student learning of the concepts in these units 6
Can I use computers with these units 7
Where can I get additional applications based materials 7
Summary 7
References 7

Unit 1: Ratios

Abstract. Beginning with ratio of diameter to circumference of circles and continuing with gear ratios in a bicycle, and ending with Ohm's Law, this unit develops the concepts of ratio and proportional relationships.

Lesson 1: Radius, diameter, and circumference 3
Lesson 2: How far do wheels travel? 7
Lesson 3: Ratios 13
Lesson 4: Scale drawing 17
Lesson 5: Putting it all together 21
Lesson 6: Proportions 23
Lesson 7: Inverse proportions 27
Lesson 8: Ohm's Law 33

Unit 2: Systems of Equations

Abstract. Linear equations are used to describe the dimensions of pipes and washers, and a variety of procedures are presented for solving such equations.

Introduction 3
Lesson 1: Writing linear relations 4
Lesson 2: Linear equations 7
Lesson 3: Solving break-even problems with graphs 15
Lesson 4: Solving systems of equations graphically 19
Lesson 5: Solving systems of equations by substitution 24
Lesson 6: Solving systems of equations by simultaneous solution 33
Lesson 7: (Optional) Determining the break-even point of a small business 42

Module 3: Prototype Units in Science

Introductory comments for teachers

Abstract. Discusses equipment needs and other issues related to the use of the prototype units.

Overview 3
Implementation 3
Notes about the units 3
Evaluation 3
Science unit preview 4
Equipment & software for units 4

Units 1, 2 and 3

Unit 1: Robotics 3

Abstract. A general science unit with high utilization of technology.

Unit 2: Wave motion and light 4

Abstract. A physical science unit with low, medium, and high utilization of technology.

Unit 3: Microscope investigations 6

Abstract. A life science skills unit with low, medium, and high utilization of technology.

144

Unit 4: Spectrophotometry

Abstract. A chemistry unit on instrumental methods of analysis. Can be taught at low, medium, or high levels of technology use.

Introduction 3
Sample lesson unit for Tech Prep chemistry 4
  Integration level 1: Independent chemistry teacher 4
  Integration level 2: With an electronics teacher 6
  Integration level 3: A team of teachers (math & English) 7
  Implementation level 1: Low cost technology 8
  Implementation level 2: Moderate technology 10
  Implementation level 3: Advanced technology 16
  Recommended level 4: Advanced technology 19
  Recommended applications: Applied technology 19
Course outline 20
Unit outline/schedule 21

Module 4: Prototype Units in Technology

Introductory Comments for Teachers

Abstract. Importance of competency based instruction and guidelines for developing competency based curricula for technology. Tech Prep instructional strategies are discussed in the context of technology.

Module 4 Table of Contents iii

The technology teacher in Tech Prep 1
Competency-based instruction (CBI) 2
  Why CBI 2
  Are your courses competency based 2
  Overview of competency based instruction 3
  How to write CBI units 6
  Scope statement worksheet 7
  Tips for teachers when writing "Duties" 8
  Tips for teachers when writing "Tasks" 9
Tech Prep Instructional Strategies 10
  Cooperative learning 10
  Learning styles 11
  Learning theories 11
  Decision making 12
  Problem solving 13
  Project activity 1: Environmental concerns 14
  Project activity 2: Video Yearbook 16
Overview of the Problem Solving Process 18
  Situation acceptance 19
  Analysis 19
  Brainstorming 19
  Morphological forced connections 19

Module 4 (cont.)

Classroom Application of the Problem Solving Process 21
Evaluating students on the Problem Solving Process 22
Glossary 23
References 24

Unit 1: Experiences in Technology

Abstract. Examples of scope statement and one duty, including its associated tasks, is shown to provide examples of Phases 1, 2, and 3 of CBI curriculum development as described in the Introductory Comments for Teachers.

Scope statement 3
Phase 1 3
Phase 2: Task 1: Identify major internal components of an IBM computer . 4
Phase 2: Task 2: Use the format command 5
Phase 2: Task 3: Use the copy command 5
Phase 2: Task 4: Perform hard drive management operations 6
Phase 2: Task 5: Manipulate data input devices 7
Phase 2: Task 6: Use desk accessory applications 7
Phase 2: Task 7: Perform diskette management operations 8
Technology preparation proficiencies 9

Unit 2: Integrated Material Handling

Abstract. This unit integrates activities in mathematics, science, and communications during the development of concepts on material handling.

Introduction 3
Suggested competencies 3
Integrated activities matrix 4
Material handling unit 5
Overview of conveyer belts 6
Overview of Just-in-Time 7
Design brief: Automated manufacturing material handling processes 8
Lesson plan: Day 1 9
Lesson plan: Day 2 9
Lesson plan: Day 3 10
Log sheet 11
Lesson plan: Day 4 12
Suggested table for time and motion study 12
Lesson plan: Day 5 13
Suggested table for time and motion study 13
Homework 14
Glossary 15
References 16

Unit 3: Environmental Design

__Abstract__. Students are taught to design and text a water purification unit suitable for home use.

Introduction 3
Tech Prep drafting/CAD and the design process 3
Overview of water purification 3
Table 1: Water Treatment System vs. Common Contaminants 5
Integration activities matrix 7
Possible topics for discussion 7
Design brief 9
Lesson plan: Day 1 9
Possible ideation topics 10
Lesson plan: Day 2 11
Lesson plan: Day 3 11
Lesson plan: Day 4 12
Lesson plan: Day 5 12
Lesson plan: Day 6 13
References 14

Module 5: An Interdisciplinary Module on Bar Coding

__Abstract__. This module provides background information about bar coding technology followed by abbreviated lesson plans presented in the form of "design briefs." There are design briefs dealing with technology, language arts, mathematics, and science. The unit illustrates instruction that involves several subjects integrated through a particular workplace application.

Background for Teachers

Introduction 3
Background on bar coding 4
    Automatic identification and automatic data collection 4
    Reasons for auto ID 5
Bar coding technology 5
    Reading bar codes 5
    Scanner types 5
Common bar code symbologies 6
    Codabar 7
    Code 128 8
    Interleaved 2 of 5 9
    Postnet 10
    Code 39 11
    Universal product code 12
Classroom applications of bar codes 14
Troubleshooting 16
Bar coding in the future 16
Glossary 17
Reference list of bar coding software and hardware vendors 19
Handouts and examples 21
    Graphic 1: Auto ID is Keyless Data Entry 22
    Graphic 2: There is No "Best" Auto ID Technology 23

147

Module 5 (cont.)

Graphic 3: How Bar Code Scanners Work 24
Graphic 4: Discreet vs. Continuous Codes 25
Graphic 5: Mag Stripe Overview 26
Graphic 6: Radio Frequency Identification 27
Graphic 7: Various Types of RFID 28
Graphic 8: Keyboard Interface Driver "Wedge" 29
New York Times Article: For Bar Codes, an Added Dimension . . . 30

Language Arts Design Briefs

Abstract. This unit presents sample projects, called Design Briefs, for language arts teachers who make use of the material presented in Background for Teachers. These projects were designed to be used in concert with projects in Mathematics Design Briefs, Science Design Briefs, and Technology Design Briefs.

The role of language arts in the interdisciplinary Tech Prep classroom . . . 3
Design Brief 1: Technical writing: Documentation for computer software . 4
Design Brief 2: Multimedia presentation 7
Design Brief 3: Sales presentation 10
Design Brief 4: Creative Writing 13

Mathematics Design Briefs

Abstract. This unit presents sample projects, called Design Briefs, for mathematics teachers who make use of the material presented in Background for Teachers. These projects were designed to be used in concert with projects in Language Arts Design Briefs, Science Design Briefs, and Technology Design Briefs.

The role of mathematics in the interdisciplinary Tech Prep classroom 3
Design Brief 1: Cracking a bar code 5
Design Brief 2: Finding the missing check number 6
Design Brief 3: Cracking another bar code 7
Design Brief 4: Is the UPC-A scheme sufficient 8
Design Brief 5: Revising the UPC-A system 9
Design Brief 6: Coding errors: Which ones get through 10
Design Brief 7: Coding errors: Comparing two bar codes 11
Design Brief 8: Using binary numbers 12
Design Brief 9: Measurement and area 13
Other math bar code topics for consideration 14
Student Glossary 15
References 16

Science Design Briefs

Abstract. This unit presents sample projects, called Design Briefs, for science teachers who make use of the material presented in Background for Teachers. These projects were designed to be used in concert with projects in Language Arts Design Briefs, Mathematics Design Briefs, and Technology Design Briefs.

The role of science in the interdisciplinary Tech Prep classroom 3
Design Brief 1: Scanner analysis 4
Design Brief 2: Scanner research document 6
Design Brief 3: Spectroscopy 8
Design Brief 4: Holography 11

Technology Design Briefs

Abstract. This unit presents sample projects, called Design Briefs, for Technology teachers who make use of the material presented in Background for Teachers. These projects were designed to be used in concert with projects in Language Arts Design Briefs, Mathematics Design Briefs, and Science Design Briefs.

The role of technology in the interdisciplinary Tech Prep Classroom 3
Design Brief 1: I've been on the line 4
Table 1: UPC Encodation Scheme 5
Design Brief 2: Move that pallet, stack that box 6
Design Brief 3: Clock me in 8

DIVISION II: OVERVIEW

by
J. Dudley Herron
Professor of Science Education
Department of Curriculum and Instruction
Purdue University

Abstract

This overview discusses preservice teacher education needs for Tech Prep and provides an introduction to the instructional modules contained in Division II. This overview will be primarily of interest to college and university teacher educators.

Indiana Tech Prep Training Materials: Division II
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

DIVISION II: OVERVIEW

Introduction

If the school reform movement of which Tech Prep is a part is to succeed, preservice teacher education must include features of that movement, and teachers emerging from those programs must be prepared to teach courses that are part of a Tech Prep program. In order to decide how teachers should be prepared, we must consider how Tech Prep differs from other programs.

What is Different About Tech Prep

Division I, Chapter 1 provides a general introduction to Tech Prep. As indicated by the Indiana Tech Prep Model summarized in Figure 1-3, Tech Prep involves English/language arts, mathematics, and science as well as vocational/technical education. It is decidedly not "just a vocational/technical education program."

Knowledge base for Tech Prep. With the possible exception of greater emphasis on keyboarding and other computer related skills, there is no new content knowledge associated with Tech Prep. Tech Prep students are expected to learn the same language arts skills and the same math and science concepts that have traditionally been learned by students preparing for college. Tech Prep students are expected to be good problem solvers and to know how to work effectively in teams--intellectual skills that have always been valued. Tech Prep adds no new content to the school curriculum.

Student base for Tech Prep. What is new about Tech Prep is that *all* students and not just the top twenty percent are expected to understand math and science, to be good problem solvers, and to work effectively in teams. If teachers require new knowledge in order to teach in a Tech Prep program, it is new knowledge about how students learn and how to make difficult ideas meaningful to all students. The challenge of Tech Prep is to teach well-established concepts and principles in mathematics and science and well-established concepts and skills in the language arts to all students.

Instructional organization for Tech Prep. Division I, Chapter 3 describes three essential elements of Tech Prep: applied academics, integrated subjects, and competency based curriculum.

Applied academics. The primary strategy advocated for making math and science accessible to Tech Prep students is "applied academics."[1] The ideas behind applied academics are not unique to Tech Prep. The 1989 National Council of Teachers of Mathematics standards for school mathematics curricula point out that "[a]lthough mathematics is not taught in schools solely so students can get jobs, . . . in-school experiences [must] reflect to some extent those of today's workplace." (NCTM, 1989, p. 4)

---

[1] Applied Academics is described in Division I, Chapter 3, in Chapter 3 of Hull and Parnell (1991), and in Grubb, et al. (1991).

Included in the NCTM list of mathematics topics to receive increased attention are the following:

- *The use of real-world problems* to motivate and apply theory [in algebra]
- *Real-world applications* and modeling [in geometry]
- *Realistic applications* and modeling [in trigonometry]
- Functions that are constructed as *models of real-world problems*" (NCTM, 1989, p. 126, emphasis added)

The AAAS Project 2061 (AAAS, 1989), the NSTA Project on Scope, Sequence and Coordination of Secondary School Science (NSTA, 1990) and other projects aimed at improving science education advocate similar goals. The National Assessment Governing Board states:

> There is unanimity in [the reports we reviewed] about the goals of science education:
>
> . . .
>
> - All American students should *acquire the ability to relate scientific concepts to each other and to problems that students encounter in and out of school,*
> - All American students should acquire the inclination to *apply their science knowledge in practical ways*; . . ."(NAGB, May 31, 1991, pp. 12-13, italics added for emphasis)

Integrated subjects. Tech Prep goes beyond the recommendations of the National Council of Teachers of Mathematics and the various science bodies and calls for more integration of subjects, in particular the integration of academic subjects such as English, mathematics, and science with vocational and technical subjects. The call for more interdisciplinary instruction is not new, but there is little evidence of such instruction in schools.

Competency based curriculum. The third characteristic of Tech Prep instructional organization is competency based instruction. Like its call for integrated subjects, the idea is not new, but it is not common practice.

Teaching strategies for Tech Prep. Applied academics implies something about teaching strategies as well as curriculum organization. In addition to suggesting that teachers present academic concepts through workplace applications, Tech Prep encourages the use of cooperative learning groups, a focus on problem solving, and enough variety in the learning activities to appeal to a variety of learning styles. These teaching strategies and their implications for Tech Prep are discussed in Chapter 4 of Division I.

Implications for Preservice Teacher Education

Teaching strategies. The teaching strategies advocated by Tech Prep are the same as those advocated by leaders in other fields. Quoting again from the NAGB report:

> There also are similarities in the recommendations across [the reports we reviewed] on the science curricula and instruction needed to achieve these goals:
>
> - *Multi- and interdisciplinary approaches to science teaching;*
> - Reduction of traditional breadth of coverage in favor of greater depth, especially in high school science;
> - *Emphasis on development of such thinking processes as organizing factual knowledge around major concepts, defining and solving problems, accessing information and reasoning with it, and communicating with others about one's science results and understandings;*
> - *Approaches that encourage active student engagement and active participation such as hands-on science in elementary school; learning in small, cooperative groups; reflecting orally and in writing upon experience; and completing sustained projects;*
> - Increase in participation of under-represented populations in challenging school science;
> - Reform in the structure and organization of school science in order to allow greater flexibility." (NAGB, May 31, 1991, pp. 12-13, italics added for emphasis)

Most of these ideas have been a part of teacher education programs for decades, and teaching strategies like cooperative learning and problem solving are emphasized in most preservice teacher education programs today. Still, some adjustments in preservice teacher education may be in order.

Effect of specialization on teaching integrated subjects. As knowledge increases, so does specialization. Physics majors know little about chemistry, and chemistry majors know little about biology. Going beyond science to mathematics, English, or technology, the overlap is even less. English, mathematics, and science teachers may be quite ignorant of workplace or other real-world applications that can be used as a vehicle for teaching concepts, principles, and skills that characterize their disciplines. In like manner, technology teachers may not understand the mathematics and science undergirding the technology that they teach. If Tech Prep and like-minded school reform is to succeed, there must be more communication and greater collaboration among teachers from different disciplines.

If an English teacher[2] has assistance from personnel in business and industry or from informed technology teachers when courses are being planned, it will be possible to develop instructional materials that are responsive to literacy concerns in the workplace and even to develop interdisciplinary units that can be taught by the English teacher alone. That is the assumption inherent in The Personal Job Search unit in Language Arts Module that follows. However, in the absence of on-going interactions between the English teacher and those with workplace knowledge, such materials quickly become dated.

---

[2] Although English is taken as an example in this discussion, the same argument can be made for science or mathematics.

Teaming an English teacher with a technology teacher insures on-going interaction across disciplines. Organizing instruction in this way enhances the probability that connections between disciplines will be made over an extended period of time. That is the rationale for Unit 2 in the Language Arts Module, Create-a-Product. Still, both teachers can lose touch with the business/industry context that is sought in Tech Prep. The broader the collaboration and the more institutionalized the processes through which cross-disciplinary interactions take place, the more likely Tech Prep will enjoy long-term success. This will not happen if such collaborative efforts are not part of the preservice education of teachers.

Instructional units in the five modules that follow illustrate the instructional content and instructional strategies that should characterize Tech Prep. Examining those units will not, however, prepare preservice teachers to function in a Tech Prep environment. To do that, teachers must participate in the process of producing such units.

Levels of collaboration. The units that follow illustrate three levels of collaboration by Tech Prep teachers. It seems reasonable that similar collaboration during preservice teacher education would be helpful.

Level I: Alone. The instructional units that follow this overview suggest that the lowest level of Tech Prep implementation would involve a single teacher using workplace applications, cooperative learning, and problem solving to teach his or her subject in a conventional school organization. Preparation for this low-level implementation of Tech Prep could be achieved with little change in preservice teacher education.

At the simplest level, students in a single discipline could develop units similar to those that follow. By using library resources and by consulting with faculty and students in other departments, students could produce interdisciplinary units organized around workplace applications, and they could incorporate cooperative learning and problem solving as teaching strategies. Depending on the emphasis placed on integrating subjects in the unit, the activity could be a vehicle for overcoming students' narrow specialization and broaden their perspective. Assignments of this kind, though not standard fare, are not unheard of in existing methods courses. They represent a step in the right direction, but they are not enough.

Level 2: Teaming. The major problem with preservice teachers developing instructional units alone or with same-subject peers is that they are never challenged "to see oursel's as ithers see us." Even teachers of closely related subjects find it difficult to view concepts from the perspective of the other field. This is clear from the experience of science and mathematics teachers enrolled in a seminar on concept learning. Students were required to do "concept analyses"[3] of key concepts in their respective disciplines. Several concepts--especially ones common to science and mathematics--were problematic. "Variable," for example, was troublesome. Students and instructors were never able to arrive at an analysis that was acceptable to both scientists and mathematicians, but everyone came away with a greater appreciation of how differently they viewed the world.

---

[3] Concept analysis is a term used by Herbert Klausmeier and others (c.f., Klausmeier, et al., 1974) to describe a formal procedure for clarifying the meaning of concepts.

By placing students from different disciplines in a common methods course *that is team taught by faculty from those disciplines*, preservice teachers could better appreciate the differances that impede communication across disciplines and thwart interdisciplinary collaboration. Placing students from different disciplines in the same course is common enough, but it is not common for such courses to be team taught or for the instructors to focus on ways that different disciplines can be taught through common applications. Neither is it common for students in these courses to collaborate on the development of interdisciplinary instructional materials. If preservice teachers collaborate with peers from another discipline to develop interdisciplinary units, and if instructors from different disciplines critique the units from the perspective of their respective disciplines, students should be better prepared to continue such collaboration in schools.

Level 3: Faculties. The logical extension of Level 2 is to conduct the same kind of collaboration but do it with students from several disciplines rather than two. One scenario might be to "appoint" students as faculty in a fictitious secondary school that is implementing Tech Prep and ask them to develop a curriculum for the program. Students should have access to the units in the following modules as well as commercial materials such as Principles of Technology, Applied Mathematics, Applied Communications, and Applied Biology and Chemistry. As in the case of Level 2, the primary benefit of this instruction is that students should come away with a better understanding of the educational concerns and points of view common to other disciplines.

Collaboration with Inservice Teachers (PDS). Many Schools of Education are establishing Professional Development Schools which provide close collaboration between the college and the public schools. Where such arrangements exist, students and inservice teachers could collaborate in the development of teaching units to their mutual benefit. This would represent a level of collaboration that goes beyond that illustrated by the following units.

Discussion of the Instructional Modules

Each of the modules that follow was developed for particular audiences, and the modules vary in organization and style. The writing teams that produced them knew that teachers in different disciplines have different adjustments to make, and each team focused on the issues that they considered most important in their particular field.

What the modules have in common. All of the units, regardless of subject, emphasize learning through applications, cooperative learning, and problem solving. All provide sample lesson plans and objectives for the units. All are based on a competency based curriculum model.

How the modules differ. The mathematics team felt that mathematics teachers would need clear examples of applications based instruction, and they developed extensive lesson plans to illustrate that approach. The technology team, on the other hand, knew that applications based instruction is standard fare in their discipline. They focused attention on competency based instruction, outlining a model for organizing technology instruction around specific competencies and then describing a unit developed according to that model. Laboratory equipment is a common concern in science classes, and the science team gave more attention to teaching Tech Prep with little or no equipment than did other writing teams. The English/language arts team gave particular attention to the correlation of unit objectives with general Tech Prep goals and the Indiana Language Arts Proficiencies.

Who the modules are for. Teachers will be most interested in the modules developed for their own subject area, but each module contains ideas of value to all subject areas.

The matrices in the Language Arts Module that are used to correlate unit objectives with general Tech Prep goals and State Proficiencies provide a model that can be adapted to any subject area. It is worth studying, regardless of your teaching area.

All of the writing teams assumed that performance based instruction would be employed to teach their units, but only the technology module presents a detailed discussion of how competency based curricula might be developed. Although some of the language employed (duties and tasks, for example) is more appropriate for technology courses than for academic courses, the procedures that are outlined can be adapted to any subject.

What kind of student materials are used in Tech Prep? There is no single answer to this question, but the materials in the mathematics module provide a useful example.

Both preservice and inservice teachers are encouraged to examine units from all five modules. None represents a definitive example of the "perfect" Tech Prep curriculum materials, but together they provide a representative sampling of ideas that can make any Tech Prep curriculum successful.

REFERENCES

American Association for the Advancement of Science (1989). *Project 2061: Science for all Americans*. Washington, D.C.: Author.

Herron, J. D., Agbebi, E., Cottrell, L., & Sills, T. (1976). Concept formation as a function of instructional procedures or what results from ineffective teaching. *Science Education*, *60*, 375-388.

Herron, J.D., Cantu, L., Ward, R., & Srinivasan, V. (1977). Problems associated with concept analysis. *Science Education*, *61*, 185-199.

Klausmeier, H., Ghatala, E., & Frayer, D. (1974). *Cognitive learning and development: A cognitive view*. New York: Academic Press.

National Assessment Governing Board (May 31, 1991). *1994 NAEP assessment framework*. Council of Chief State School Officers, 379 Hall of the States, 400 North Capital St., N.W., Washington, D.C. 20001-1511: Author. Quoted in ASCD (1991). *ASCD curriculum handbook*. Alexandria, VA: Association for Supervision and Curriculum Development, pp. 5.12-5.13.

National Council for Teachers of Mathematics (1989). *Curriculum and evaluation standards for school mathematics*. 1906 Association Drive, Reston, VA 22091: Author.

National Science Teachers Association (1990). *Project on scope, sequence and coordination of secondary school science*. Washington, D.C.: Author.

MODULE 1: LANGUAGE ARTS

UNIT 1

THE PERSONAL JOB SEARCH

by

James E. Green
Ball State University

Carolyn Hardy
North Montgomery High School

Lori Hoevenor
Bloomington North High School

Abstract

This unit incorporates applications based instruction, problem solving, cooperative learning, and other features of Tech Prep, but without requiring ongoing collaboration between two or more teachers. It shows how Tech Prep can be implemented in schools that are unable to establish collaboration across subject areas as a permanent part of the curriculum.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

THE PERSONAL JOB SEARCH

Introduction

In today's competitive world students must be able to present themselves in a professional way. Since entry into the world of commerce depends upon first obtaining the right position, students must learn to approach the job interview process systematically and skillfully. This unit attempts to familiarize students with this process by focusing on the oral and written proficiencies required to compete successfully.

Student characteristics that are necessary for success in "The Personal Job Search" include average ability in oral and written communication. In addition, this unit requires keyboarding skills and familiarity with a word processing program.

In the experience of teachers who have used this unit, student interest runs high. Students understand the need for quality in the preparation of personal information before, during, and after the job search process, and they appreciate the edge that quality provides. Students are motivated also by the tangible results that come from success in the job search: a job offer.

"The Personal Job Search" has been successfully taught in two different contexts: a large school (1250 students) in southern Indiana and a small school (650 students) in central Indiana. Both schools exhibit a high level of commitment to Tech Prep. The small school has chosen to focus the language arts Tech Prep curriculum at the junior level, during which students in Tech Prep take a course titled "Oral/Written Communications." In contrast, the large school has integrated Tech Prep concepts and methods into classes that have traditionally served the general education student.

"The Personal Job Search" previously has been taught in Tech Prep classrooms where the English teachers find that their instruction occasionally is separate from that of other Tech Prep subject areas. While one of the essential elements of the Tech Prep curriculum is its interdisciplinary character, with multiple subject areas and several teachers working cooperatively and simultaneously, implementation in real school settings often requires a more flexible approach. It is frequently necessary for an English teacher to design and teach units based on strategies emphasized in Tech Prep (*e.g.*, applications based instruction, problem solving, cooperative learning, and learning styles) within the English curriculum and without the participation of teachers from other departments in the school. Such independent implementation of Tech Prep does not mean, however, that the Tech Prep hallmarks of the application of technology and knowledge from other subjects to solve problems should not be incorporated in the English unit. But rather, it simply recognizes that there are occasions when the English teacher will not have the opportunity to work in conjunction with another or several other teachers on a purely interdisciplinary unit. "The Personal Job Search" allows the English teacher to teach in the Tech Prep style, but does not require complete overhaul of the school's curriculum or class schedule in order to do so.

Unit Overview

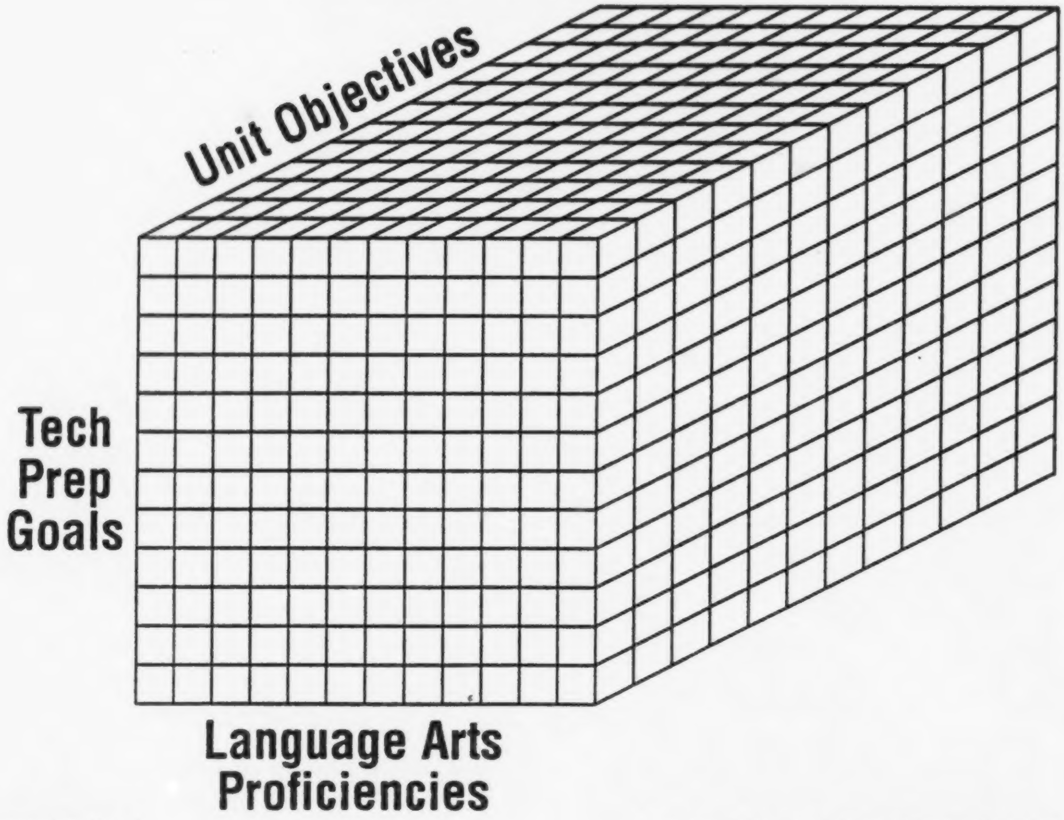
"The Personal Job Search" is designed to involve students in an individual and cooperative learning experience which moves through the essential steps of a job search.

Individual oral and written communication skills are key concepts in this unit. Cooperative learning is utilized while students work toward personal products that include oral interviews, resumes, letters of application, cover letters, thank you letters, and application forms. The oral communications component will provide listening techniques, nonverbal communication, interpersonal communication, and communication in dyads. In addition, students will develop the skills needed to select career areas and conduct job searches. The unit is planned for approximately three weeks.

An important feature of "The Personal Job Search" is the use of local business and industry personnel. Involving community leaders from business and industry in the final project for the unit helps motivate students to do their best work. It also helps the teacher to evaluate the success of the unit and plan for improvements. Technology necessary for the unit includes microcomputers, word processing programs, letter quality printers, and video recording equipment. Optional technology includes graphics capabilities for the microcomputers, laser printers, and access to electronic data retrieval systems for job searches.

Figure 1

Model for Goals, Proficiencies, and Objectives for a Tech Prep English Unit



General Objectives

What students accomplish in any unit will depend on what you plan for them to accomplish. Objectives are the essence; and, content and activities are determined by the objectives. In this unit objectives are considered from three perspectives. First, what are the goals for any Tech Prep unit? Second, what are the general proficiencies for any language arts program? Finally, what are the general objectives for this specific unit? When we take Tech Prep goals and general language arts proficiencies into consideration, the objectives for a Tech Prep unit in English end up having a three dimensional structure. One dimension consists of the Tech Prep goals, another includes language arts proficiencies, and the third is made up of the objectives that are unique to that unit. This three dimensional structure is depicted in Figure 1, Model for Goals, Proficiencies, and Objectives in a Tech Prep English Unit.

Tech Prep goals, of course, are not prescribed. Various Tech Prep regions or individual schools will develop their own statements on Tech Prep goals. For the purpose of developing this unit on "The Personal Job Search," the goals expressed in the SCANS Report (1991) were used. These goals are enumerated in Figures 2 and 3 for reference by teachers who will be developing their own Tech Prep units in language arts.

English teachers should also keep the general proficiencies for language arts in mind when preparing the instructional objectives for any unit. The proficiencies for language arts developed by the Indiana Department of Education are very useful for this purpose. These proficiencies have been edited so that they are specific to the secondary curriculum, and they are enumerated in Figure 4. (The language arts proficiencies listed in this unit were still designated to be in the "draft" stage of development by the Indiana Department of Education at the time this manual was prepared.)

The objectives for the unit are listed in Figure 5, and they are repeated in a matrix format so that it is plain how the unit objectives integrate with Tech Prep goals and with the state proficiencies. Teachers who plan to develop their own Tech Prep units might be assisted by using this same format in order to be sure to consider some of the overarching principles of Tech Prep and state proficiencies at the basic stage of instructional planning. See Figure 6, Unit Objectives and Tech Prep Goals (Foundations), Figure 7, Unit Objectives and Tech Prep Goals (Competencies), and Figure 8, Unit Objectives and Language Arts Proficiencies to see how the unit objectives relate to overall Tech Prep objectives and to the state proficiencies.

Figure 2

A THREE-PART FOUNDATION

Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks

A. *Reading*: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules
B. *Writing*: Communicates thoughts, ideas, information, and messages, in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts
C. *Arithmetic/Mathematics*: Performs basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques
D. *Listening*: Receives, attends to, interprets, and responds to verbal messages and other cues
E. *Speaking*: Organizes ideas and communicates orally

Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn, and reasons

A. *Creative Thinking*: Generates new ideas
B. *Decision Making*: Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative
C. *Problem Solving*: Recognizes problems and devises and implements plan of action
D. *Seeing Things in the Mind's Eye*: Organizes, and processes symbols, pictures, graphs, objects, and other information
E. *Knowing How to Learn*: Uses efficient learning techniques to acquire and apply knowledge and skills
F. *Reasoning*: Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem

Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

A. *Responsibility*: Exerts a high level of effort and perseveres towards goal attainment
B. *Self-esteem*: Believes in own self-worth and maintains a positive view of self
C. *Sociability*: Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings
D. *Self-management*: Assesses self accurately, sets personal goals, monitors programs, and exhibits self-control
E. *Integrity/Honesty*: Chooses ethical

Figure 3

FIVE COMPETENCIES

Resources: Identifies, organizes, plans, and allocates resources

A. *Time*: Selects goal-relevant activities, ranks them, allocates time, and prepares and follows schedules
B. *Money*: Uses or prepares budgets, makes forecasts, keeps records, and makes adjustments to meet objectives
C. *Material and Facilities*: Acquires, stores, allocates, and uses materials or space efficiently
D. *Human Resources*: Assesses skills and distributes work accordingly, evaluates performance and provides feedback

Interpersonal: Works with others

A. *Participates as a Member of a Team*: Contributes to group effort
B. *Teaches Others New Skills*
C. *Serves Clients/Customers*: Works to satisfy customers' expectations
D. *Exercises Leadership*: Communicates ideas to justify position, persuades and convinces others, responsibly challenges existing procedures and policies
E. *Negotiates*: Works toward agreements involving exchange of resources, resolves divergent interests
F. *Works with Diversity*: Works well with men and women from diverse backgrounds

Information: Acquires and uses information

A. *Acquires and Evaluates Information*
B. *Organizes and Maintains Information*
C. *Interprets and Communicates Information*
D. *Uses Computers to Process Information*

Systems: Understands complex inter-relationships

A. *Understands Systems*: Knows how social, organizational, and technological systems works and operates effectively with them
B. *Monitors and Corrects Performance*: Distinguishes trends, predicts impacts on system operations, diagnoses systems' performance and corrects malfunctions
C. *Improves or Designs Systems*: Suggests modifications to existing systems and develops new or alternative systems to improve performance

Technology: Works with a variety of technologies

A. *Selects Technology*: Chooses procedures, tools, or equipment including computers and related technologies
B. *Applies Technology to Task*: Understands overall intent and proper procedures for setup and operation of equipment
C. *Maintains and Troubleshoots Equipment*: Prevents, identifies, or solves problems with equipment, including computers and other technologies

---

Figure 4

Indiana Department of Education Language Arts Proficiencies

1. Exhibit a positive attitude toward language and learning through . . . participating in activities related to speech and debate, drama, journalism; submitting works for publication; entering literary, speech, and writing contests.

2A. Use developmentally appropriate materials to select and apply effective strategies for reading, including . . . reading from different points of view; making and defending judgements about quality and content, including information generated through technology.

2B. Comprehend developmentally appropriate materials, including . . . broad variety of literature, magazines and newspapers written for a general adult audience; directions on forms and products; technical procedures, as in computer use; common legal agreements.

3A. Select and use developmentally appropriate strategies for writing, including . . . choosing methods of organization appropriate to audiences and purpose; revising writing for clarity, coherence, economy, and style; preparing final drafts that adhere to accepted conventions.

3B. Write for different purposes and audiences using a variety of forms, including . . . notes and messages; syntheses of information from a variety of sources; completion of complex forms; complex directions; persuasive letters.

4. Use prior knowledge and subject area information to make critical judgements, including . . . distinguishing between objective and subjective presentations of information and events; understanding how language is used to influence; identifying bias and its implications in mass media, understanding implied meanings.

5. Communicate orally and in writing with all ages of people by . . . working collaboratively to generate ideas and solve problems; speaking effectively to an audience; expressing and defending one's own ideas; participating in interviews.

6. Recognize the inter-relatedness of language, literature, and culture . . . by reading some of the recognized masterpieces and authors; explaining how historical events are reflected in works of a given period; understanding how contemporary writing reflects past literary traditions; developing criteria for judging the quality of literary works.

Figure 5

"Personal Job Search" Unit Objectives

Upon successful completion of "The Personal Job Search" students will be able to:

1. Describe the characteristics of their "dream job" or ultimate job situation.
2. Identify their personal job interests.
3. Design an occupational cluster depicting personal job interests.
4. Share their occupational clusters with other students through oral communication.
5. Survey job information.
6. Identify and locate occupation, job, and career resources.
7. Utilize data resources to obtain information about careers and jobs.
8. Identify information typically included in job ads.
9. Critically read job ads.
10. Identify written communication components involved in the job search.
11. Identify the components of a resume.
12. Write a resume.
13. Identify the components of a letter of application.
14. Write a letter of application.
15. Identify the components of a cover letter.
16. Write a cover letter.
17. Identify the components of a thank you letter.
18. Write a thank you letter.
19. Utilize wordprocessor to compose written materials needed for a job search.
20. Complete job application forms accurately and completely.
21. Identify the oral communication skills essential to a successful job search.
22. Exhibit poise and confidence in a job interview.
23. Use standard English in a job interview.
24. Exchange information in a role-playing activity.
25. Prepare for videotaped interview.
26. Demonstrate appropriate posture in a job interview.
27. Utilize professional vocabulary appropriate for a given interview.
28. Dress in appropriate, business-like attire.
29. Interact interpersonally in a poised, confident, and articulate manner in an interview.
30. Determine the strengths of his/her educational background and work experience.
31. Conduct a personal critique and self-evaluation of performance in a job interview.

Figure 6
Tech Prep Goals (Foundations) and Unit Objectives

Unit Objectives	Basic Skills: Reading	Basic Skills: Writing	Basic Skills: Math	Basic Skills: Listening	Basic Skills: Speaking	Thinking Skills: Creative Thinking	Thinking Skills: Decision Making	Thinking Skills: Problem Solving	Thinking Skills: Processing	Thinking Skills: Learning to Learn	Thinking Skills: Reasoning	Personal Qualities: Responsibility	Personal Qualities: Self-esteem	Personal Qualities: Sociability	Personal Qualities: Self-management	Personal Qualities: Integrity/Honesty
Describe the characteristics of their "dream job" or the ultimate job situation.		✓				✓							✓			
Identify their personal job interests.															✓	
Design an occupational cluster depicting personal job interests.	✓								✓	✓			✓			
Share their occupational clusters with other students through oral communication.				✓	✓	✓							✓	✓		
Survey job information.	✓								✓	✓						
Identify and locate occupation, job, and career resources.	✓								✓	✓					✓	
Utilize data resources to obtain information about careers and jobs.	✓								✓	✓					✓	
Identify information typically included in job ads.	✓								✓	✓						
Critically read job ads.	✓									✓	✓					

Figure 6
Tech Prep Goals (Foundations) and Unit Objectives

Unit Objectives \ **Tech Prep Goals**	Basic Skills: Reading	Basic Skills: Writing	Basic Skills: Math	Basic Skills: Listening	Basic Skills: Speaking	Thinking Skills: Creative Thinking	Thinking Skills: Decision Making	Thinking Skills: Problem Solving	Thinking Skills: Processing	Thinking Skills: Learning to Learn	Thinking Skills: Reasoning	Personal Qualities: Responsibility	Personal Qualities: Self-esteem	Personal Qualities: Sociability	Personal Qualities: Self-management	Personal Qualities: Integrity/Honesty
Identify written communication components involved in the job search.		✓								✓						
Identify the components of a resume.		✓														
Write a resume.		✓											✓		✓	
Identify the components of a letter of application.		✓														
Write a letter of application.		✓														✓
Identify the components of a cover letter.		✓														
Write a cover letter.		✓														
Identify the components of a thank you letter.		✓														
Write a thank you letter.		✓														
Utilize wordprocessor to compose written materials needed for job search.		✓														

Figure 6
Tech Prep Goals (Foundations) and Unit Objectives

	Tech Prep Goals															
Unit Objectives	Basic Skills: Reading	Basic Skills: Writing	Basic Skills: Math	Basic Skills: Listening	Basic Skills: Speaking	Thinking Skills: Creative Thinking	Thinking Skills: Decision Making	Thinking Skills: Problem Solving	Thinking Skills: Processing	Thinking Skills: Learning to Learn	Thinking Skills: Reasoning	Personal Qualities: Responsibility	Personal Qualities: Self-esteem	Personal Qualities: Sociability	Personal Qualities: Self-management	Personal Qualities: Integrity/Honesty
Complete job application forms accurately and completely.		✓										✓				✓
Identify the oral communication skills essential to a successful job search.				✓	✓											
Exhibit poise and confidence in a job interview.				✓	✓								✓	✓		
Use standard English in a job interview.					✓											
Exchange information in a role-playing activity.				✓	✓											
Prepare for videotaped interview.												✓			✓	
Demonstrate appropriate posture in a job interview.												✓	✓			
Utilize professional vocabulary appropriate for a given interview.					✓											
Dress in appropriate, business-like attire.												✓	✓			

Figure 6
Tech Prep Goals (Foundations) and Unit Objectives

Unit Objectives	Basic Skills: Reading	Basic Skills: Writing	Basic Skills: Math	Basic Skills: Listening	Basic Skills: Speaking	Thinking Skills: Creative Thinking	Thinking Skills: Decision Making	Thinking Skills: Problem Solving	Thinking Skills: Processing	Thinking Skills: Learning to Learn	Thinking Skills: Reasoning	Personal Qualities: Responsibility	Personal Qualities: Self-esteem	Personal Qualities: Sociability	Personal Qualities: Self-management	Personal Qualities: Integrity/Honesty
Interact interpersonally in a poised, confident, and articulate manner in an interview.				✓	✓								✓		✓	
Determine the strengths of his/her educational background and work experience.														✓		
Conduct a personal critique and self-evaluation of performance in a job interview.				✓										✓		

Figure 7
Tech Prep Goals (Competencies) and Unit Objectives

Unit Objectives	Tech Prep Goals: Utilizes Time	Utilizes Money	Utilizes Materials and Facilities	Utilizes Human Resources	Participates as a Team Member	Teaches Others Skills	Serves Clients/Customers	Exercises Leadership	Negotiates	Works with Diversity	Acquires and Evaluates Information	Organizes and Maintains Information	Interprets and Communicates Information	Uses Computers to Process Information	Understands Systems	Monitors and Corrects Performance	Improves or Designs Systems	Selects Technology	Applies Technology	Maintains and Troubleshoots Equipment
Describe the characteristics of their "dream job" or the ultimate job situation.	✓												✓							
Identify their personal job interests.	✓																			
Design an occupational cluster depicting personal job interests.	✓										✓	✓								
Share their occupational clusters with other students through oral communication.					✓	✓							✓							
Survey job information.												✓								
Identify and locate occupation, job, and career resources.												✓								
Utilize data resources to obtain information about careers and jobs.												✓								
Identify information typically included in job ads.												✓								
Critically read job ads.												✓	✓							

Figure 7
Tech Prep Goals (Competencies) and Unit Objectives

Unit Objectives	Utilizes Time	Utilizes Money	Utilizes Materials and Facilities	Utilizes Human Resources	Participates as a Team Member	Teaches Others Skills	Serves Clients/Customers	Exercises Leadership	Negotiates	Works with Diversity	Acquires and Evaluates Information	Organizes and Maintains Information	Interprets and Communicates Information	Uses Computers to Process Information	Understands Systems	Monitors and Corrects Performance	Improves or Designs Systems	Selects Technology	Applies Technology	Maintains and Troubleshoots Equipment
Identify written communication components involved in the job search.												✓	✓							
Identify the components of a resume.													✓							
Write a resume.													✓							
Identify the components of a letter of application.													✓							
Write a letter of application.													✓							
Identify the components of a cover letter.													✓							
Write a cover letter.													✓							
Identify the components of a thank you letter.													✓							
Write a thank you letter.													✓							
Utilize wordprocessor to compose written materials needed for job search.													✓	✓				✓	✓	

Figure 7
Tech Prep Goals (Competencies) and Unit Objectives

Unit Objectives	Utilizes Time	Utilizes Money	Utilizes Materials and Facilities	Utilizes Human Resources	Participates as a Team Member	Teaches Others Skills	Serves Clients/Customers	Exercises Leadership	Negotiates	Works with Diversity	Acquires and Evaluates Information	Organizes and Maintains Information	Interprets and Communicates Information	Uses Computers to Process Information	Understands Systems	Monitors and Corrects Performance	Improves or Designs Systems	Selects Technology	Applies Technology	Maintains and Troubleshoots Equipment
Complete job application forms accurately and completely.	✓										✓	✓	✓							
Identify the oral communication skills essential to a successful job search.												✓	✓							
Exhibit poise and confidence in a job interview.													✓							
Use standard English in a job interview.													✓							
Exchange information in a role-playing activity.				✓									✓							
Prepare for videotaped interview.												✓	✓			✓			✓	
Demonstrate appropriate posture in a job interview.																✓				
Utilize professional vocabulary appropriate for a given interview.																✓				
Dress in appropriate, business-like attire.																✓				

Figure 7
Tech Prep Goals (Competencies) and Unit Objectives

Unit Objectives / **Tech Prep Goals**	Utilizes Time	Utilizes Money	Utilizes Materials and Facilities	Utilizes Human Resources	Participates as a Team Member	Teaches Others Skills	Serves Clients/Customers	Exercises Leadership	Negotiates	Works with Diversity	Acquires and Evaluates Information	Organizes and Maintains Information	Interprets and Communicates Information	Uses Computers to Process Information	Understands Systems	Monitors and Corrects Performance	Improves or Designs Systems	Selects Technology	Applies Technology	Maintains and Troubleshoots Equipment
Interact interpersonally in a poised, confident, and articulate manner in an interview.																	✓			
Determine the strengths of his/her educational background and work experience.																	✓			
Conduct a personal critique and self-evaluation of performance in a job interview.																	✓			

Figure 8
Language Arts Proficiencies and Unit Objectives

	Language Arts Proficiencies							
Unit Objectives	Exhibit a positive attitude toward language and learning...	Use developmentally appropriate materials to select and apply effective strategies for reading...	Comprehend developmentally appropriate materials...	Select and use developmentally appropriate strategies for writing...	Write for different audiences and purposes using a variety of forms...	Use prior knowledge and subject area information to make critical judgements...	Communicate orally and in writing...	Recognize inter-relatedness of language, literature, and culture...
Describe the characteristics of their "dream job" or the ultimate job situation.	✓			✓	✓		✓	
Identify their personal job interests.							✓	
Design an occupational cluster depicting personal job interests.								
Share their occupational clusters with other students through oral communication.							✓	
Survey job information.		✓						
Identify and locate occupation, job, and career resources.		✓						
Utilize data resources to obtain information about careers and jobs.		✓						
Identify information typically included in job ads.	✓	✓				✓		
Critically read job ads.	✓	✓				✓		

Figure 8
Language Arts Proficiencies and Unit Objectives

	Language Arts Proficiencies							
Unit Objectives	Exhibit a positive attitude toward language and learning...	Use developmentally appropriate materials to select and apply effective strategies for reading...	Comprehend developmentally appropriate materials...	Select and use developmentally appropriate strategies for writing...	Write for different audiences and purposes using a variety of forms...	Use prior knowledge and subject area information to make critical judgements...	Communicate orally and in writing...	Recognize inter-relatedness of language, literature, and culture...
Identify written communication components involved in the job search.				✓				
Identify the components of a resume.				✓	✓		✓	
Write a resume.				✓	✓		✓	
Identify the components of a letter of application.				✓	✓		✓	
Write a letter of application.				✓	✓		✓	
Identify the components of a cover letter.				✓	✓		✓	
Write a cover letter.				✓	✓		✓	
Identify the components of a thank you letter.				✓	✓		✓	
Write a thank you letter.				✓	✓		✓	
Utilize wordprocessor to compose written materials needed for job search.				✓	✓		✓	

Figure 8
Language Arts Proficiencies and Unit Objectives

Unit Objectives	**Language Arts Proficiencies** Exhibit a positive attitude toward language and learning...	Use developmentally appropriate materials to select and apply effective strategies for reading...	Comprehend developmentally appropriate materials...	Select and use developmentally appropriate strategies for writing...	Write for different audiences and purposes using a variety of forms...	Use prior knowledge and subject area information to make critical judgements...	Communicate orally and in writing...	Recognize inter-relatedness of language, literature, and culture...
Complete job application forms accurately and completely.							✓	
Identify the oral communication skills essential to a successful job search.	✓						✓	
Exhibit poise and confidence in a job interview.	✓						✓	
Use standard English in a job interview.	✓						✓	
Exchange information in a role-playing activity.	✓						✓	
Prepare for videotaped interview.							✓	
Demonstrate appropriate posture in a job interview.							✓	
Utilize professional vocabulary appropriate for a given interview.	✓						✓	
Dress in appropriate, business-like attire.							✓	

Figure 8
Language Arts Proficiencies and Unit Objectives

Unit Objectives	Exhibit a positive attitude toward language and learning...	Use developmentally appropriate materials to select and apply effective strategies for reading...	Comprehend developmentally appropriate materials...	Select and use developmentally appropriate strategies for writing...	Write for different audiences and purposes using a variety of forms...	Use prior knowledge and subject area information to make critical judgements...	Communicate orally and in writing...	Recognize inter-relatedness of language, literature, and culture...
Interact interpersonally in a poised, confident, and articulate manner in an interview.	✓						✓	
Determine the strengths of his/her educational background and work experience.	✓							
Conduct a personal critique and self-evaluation of performance in a job interview.	✓						✓	

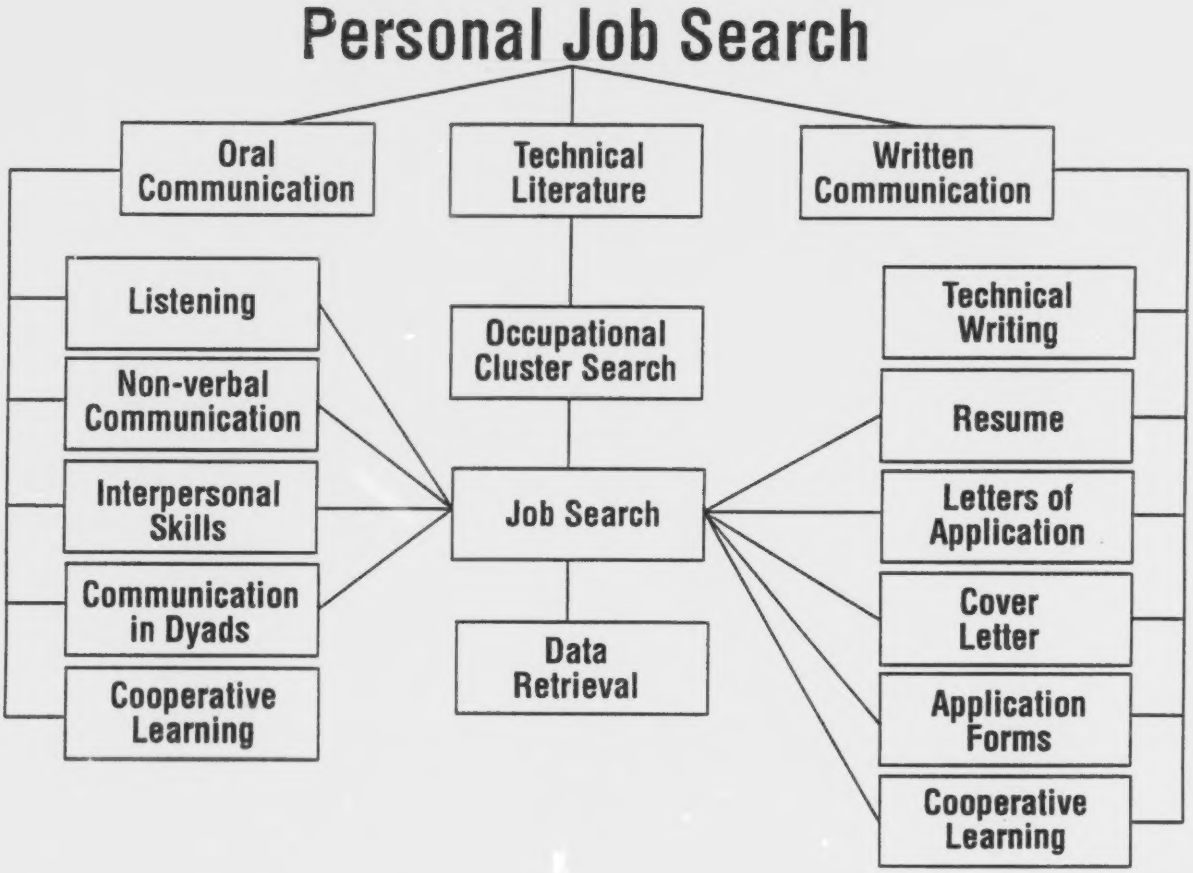
Outline for Unit Content

The outline of content for "The Personal Job Search" is presented in a conceptual framework. The overriding concepts are cooperative learning and individual skill building under which all the content of the unit is organized.

Figure 9

Conceptual Framework

for


Personal Job Search
Oral Communication
Technical Literature
Written Communication
Listening
Non-verbal Communication
Interpersonal Skills
Communication in Dyads
Cooperative Learning
Occupational Cluster Search
Job Search
Data Retrieval
Technical Writing
Resume
Letters of Application
Cover Letter
Application Forms
Cooperative Learning

Instructional Strategies

The outline of instructional strategies is presented in a matrix that depicts the characteristic Tech Prep strategies and the unit planned instructional activities. Strategies and instructional activities are presented in this form so that an English teacher can use the same format when planning a different unit. The key is monitoring the extent to which the unit's instructional activities reflect the strategies that are essential to Tech Prep.

Tech Prep Strategies

I. Alternative Learning Styles
II. Cooperative Learning
III. Problem Solving
IV. Applications Based Instruction

Unit Activities

1. Describe the "dream job."
2. Design an occupational cluster.
3. Research specific careers and jobs.
4. Critically read job ads.
5. Compose and wordprocess resume.
6. Compose and wordprocess letter of application.
7. Compose and wordprocess cover letter.
8. Compose and wordprocess thank you letter.
9. Complete job application form.
10. Prepare for job interview.
11. Interview for a job.
12. Conduct personal critique and self-evaluation of videotaped job interview.

Figure 10
Unit Activities and Instructional Strategies

Unit Activities	Alternative Learning Styles	Cooperative Learning	Problem Solving	Applications Based Instruction
Describe the "dream job."				✓
Design an occupational cluster.	✓			✓
Research specific careers and jobs.	✓	✓		✓
Critically read job ads.				✓
Compose and wordprocess resume.	✓			✓
Compose and wordprocess letter of application.	✓			✓
Compose and wordprocess cover letter.	✓			✓
Compose and wordprocess thank you letter.	✓			✓
Complete job application form.				✓
Prepare for job interview.				✓
Interview for a job.		✓		✓
Conduct personal critique and self-evaluation of videotaped job interview.				✓

LESSON ONE
"DREAM JOB" WRITING ASSIGNMENT
(1 DAY)

OBJECTIVES:

Students will be able to:

1. Describe the characteristics of their "dream job" or ultimate job situation.

ACTIVITIES:

1. Students brainstorm different occupations.
2. Students select one occupational cluster of interest to them.
3. Students will compose a casual one-page essay describing the location, responsibilities, and hours of this job.

EVALUATION:

1. Students complete writing assignment by the end of the period. The casual essay should enumerate those features that make it "a dream."
2. Students participate in the brainstorming session of future career possibilities.

LESSON TWO
OCCUPATIONAL CLUSTER
(1 DAY)

OBJECTIVES:

Students will be able to:

1. Identify personal job interests.

2. Share occupational clusters through small group discussion.

3. Design an occupational cluster depicting personal job interests.

ACTIVITIES:

1. Teacher reviews and explains the Cluster Search Method. (See sample contained in Attachment 1.) Clustering is a brainstorming activity that utilizes an open format of circles and lines that connect occupational interests.

2. Students create a personal occupation cluster. Steps include the following: 1) Identify area of interest; 2) Design the cluster placing a general interest heading at the center of the cluster; 3) Connect occupational areas of interest that are interrelated.

3. Groups of three to four members of related occupational interests will discuss and share personal clusters.

EVALUATION:

1. Students are evaluated based on the thoroughness of their clusters.

2. Students are evaluated based on their participation in their small groups according to the following criteria: 1) Do they contribute to the discussion? 2) Do they share ideas freely? 3) Do they offer suggestions to other members of their group?

REFERENCE:

Macmillan English 12: Thinking and writing processes. (1988). New York: Scribner Laidlaw. (p. 241).

LESSON THREE
DATA RETRIEVAL
(2 DAYS)

OBJECTIVES:

Students will be able to:

1. Identify and locate occupation, job, and career resources: school library, school guidance, Workforce Development Center, public library.

2. Utilize data resources such as the Occupational Outlook Handbook or other resources available through the school's guidance office and library, to locate and identify the following: 1) Nature of the work; 2) Working conditions; 3) Necessary training; 4) Advancement opportunities; 5) Job outlook; 6) Earnings; 7) Related occupations; and, 8) Sources of additional information.

ACTIVITIES:

1. Teacher presents and demonstrates the use of data sources.

2. Students work individually utilizing various data sources to locate and identify: 1) Nature of the work; 2) Working conditions; 3) Necessary training; 4) Advancement opportunities; 5) Job outlook; 6) Earnings; 7) Related occupations; and, 8) Sources of additional information.

3. Students write a topic outline listing information located in their data searches.

EVAIUATION:

1. Students are evaluated based on the utilization of three data resources.

2. Students are evaluated on the basis of the completeness of their topic outlines.

REFERENCE:

U.S. Department of Labor, Bureau of Labor Statistics. (1992). Occupational outlook handbook (1992-93 ed.). Washington, DC: Author.

LESSON FOUR
JOB SEARCH
(1 DAY)

OBJECTIVES:

Students will be able to:

1. Survey job information in job ads.
2. Critically read job ads to determine purpose of the ad.
3. Identify information typically found in a job ad.
4. Select a possible job opening.

ACTIVITIES:

1. Students individually read local newspaper help wanted sections.
2. Teacher leads class discussion covering various kinds of information found in a job ad.
3. Students work in small groups of three to four to survey other job ads and critically review the information for the following information: What's the job? What are the qualifications? What is the salary? What is the necessary education or training required? Is the ad believable? (What's the catch?) Who should be contacted and how (by phone or letter)?
4. Students select an advertised position.
5. Students write a short critical summary of a job ad based on the criteria listed in activity three.

EVALUATION:

1. Students are evaluated based on individual contributions to the class discussion concerning kinds of information found in job ads.
2. Students are evaluated based on their small group participation according to the following criteria: 1) Do they contribute to the discussion? 2) Do they share ideas freely? 3) Do they offer suggestions to the members of the group?
3. Students are evaluated based on the completeness and quality of composition of their summaries.

LESSON FIVE
WRITTEN COMMUNICATIONS
(5 TO 7 DAYS)

OBJECTIVES:

Students will be able to:

1. Identify the written communication components involved in answering a job ad and/or making application.
2. Identify the components of a resume.
3. Write a resume.
4. Identify the components of a letter of application.
5. Write a letter of application.
6. Identify the components of a cover letter.
7. Write a cover letter.
8. Identify the components of a thank you letter.
9. Write a thank you letter.
10. Utilize computer word processing in the production of the written documents used in the job application process.

ACTIVITIES:

1. Teacher presents samples of the written components used in the job application process: resume, letter of application, cover letter, and thank you letter.
2. Teacher leads series of class discussion over each of the components.
3. Students individually write resumes, letters of application, cover letters, and thank you letters utilizing computer word processing.

EVALUATION:

1. Students are evaluated based on content, accuracy, and visual appearance of written communication. The business community expects error free written communication.

REFERENCE:

Adelstein, M.D., & Davis, K. W. (1988). Business communication for the information age. Orlando: Harcourt Brace.

LESSON SIX
JOB APPLICATIONS
(1 DAY)

OBJECTIVES:

Students will be able to:

1. Complete two different job application forms accurately and completely.

ACTIVITIES:

1. Students practice completing job applications.
2. Students evaluate a partner's application for completeness of information, neatness, correct spelling, and appropriate professional vocabulary.
3. Students complete a second application to be evaluated by the teacher.

EVALUATION:

1. Peer evaluation (according to stated criteria) of first application.
2. Teacher evaluation (according to stated criteria) of second application.

REFERENCE:

Attachment 2, Job Application

LESSON SEVEN
ORAL COMMUNICATION SKILLS
(2 DAYS)

OBJECTIVES:

Students will be able to:

1. Identify the oral communication skills essential to a successful job search.
2. Exhibit poise and confidence in a job interview.
3. Use standard English in a job interview.
4. Exchange information in a role-playing activity.

ACTIVITIES:

1. Students read pages 17-21 in "Making and Responding to Requests" in Applied Communication, Module 11.
2. Students role-play one activity from pages 23-24 in this module. This activity requires students to write and perform the dialogue suggested in each scenario. Students conduct themselves in a professional manner; and, through dialogue, resolve the situation to the satisfaction of the parties involved.

EVALUATION:

1. Students complete role-playing activity.
2. Teacher evaluation of skits for professional vocabulary, poise, confidence, and interpersonal skills which result in an effective exchange of information.

REFERENCE:

Agency for Instructional Technology (1988). Making and responding to requests, Applied Communication, Module 11. Bloomington, IN: Author. pp. 17-26

LESSON EIGHT
INTERVIEW ETIQUETTE
(1 DAY)

OBJECTIVES:

Students will be able to:

1. Prepare for videotaped interview.
2. Demonstrate appropriate posture in a job interview.
3. Utilize professional vocabulary appropriate for a given interview.
4. Dress in appropriate, business-like attire.
5. Interact interpersonally in a poised, confident, and articulate manner in an interview.
6. Determine the strengths of his/her educational background and work experience.

ACTIVITIES:

1. Students read and respond to handout.
2. Students critique job interview videotape. The teacher will work with a local business person and develop a videotape of two sample job interviews (one effective and one ineffective). After viewing each videotape, students list strong and weak points.
3. The teacher leads a discussion of the important job interview skills listed above.

EVALUATION:

1. Students read and respond to presented information.
2. Students participate in class discussion to demonstrate knowledge of appropriate interview etiquette: business-like attire, professional vocabulary, poise, confident posture, positive tone, and articulate speaking style.

REFERENCE:

Adelstein, M. E., & Davis, K. W. (1988). Business communication for the information age. Orlando: Harcourt Brace

LESSON NINE
INTERVIEW PREPARATION
(1 DAY)

OBJECTIVES:

Students will be able to:

1. Prepare for videotaped interview.
2. Demonstrate appropriate posture in a job interview.
3. Utilize professional vocabulary appropriate for a given interview.
4. Dress in appropriate, business-like attire.
5. Interact interpersonally in a poised, confident, and articulate manner in an interview.
6. Determine the strengths of their educational background and work experience.

ACTIVITIES:

1. Students read list of sample interview questions (Business English and Letter Writing, pages 467-469).
2. Students work in pairs and write sample interview questions appropriate to his/her respective career choice.
3. Students practice answering sample interview questions smoothly and confidently.

EVALUATION:

1. Each student turns in a list of anticipated questions pertaining to a specific job
2. Participating in group (pairs) for practicing answering questions

REFERENCE:

Hagar, H.A., Stewart, M.M., & Hutchinson, E.L. (1953). Business English and Letter Writing. New York: McGraw-Hill.

LESSON TEN
JOB INTERVIEW
(1 DAY PER STUDENT)

OBJECTIVES:

Students will be able to:

1. Successfully complete individual, formal job interviews and demonstrate the following professional attributes: use of standard English, poise, self-confidence, appropriate seated posture, assertiveness, and appropriate dress and personal appearance.

2. Conduct a critique and self-evaluation of the video-taped personal interview. Evaluation will cover the following criteria: 1) Use of standard English; 2) Poise; 3) Self-confidence; 3) Appropriate seated posture; 3) Assertiveness; 4) Appropriate dress.

ACTIVITIES:

1. In conjunction with local business and industry, students will participate in individual general topic, video-taped interviews.

2. Following the interview, students will review and evaluate their interview based on the criteria listed in objective one.

3. OPTIONAL: Students may review/evaluate other student interviews.

EVALUATION:

1. Teacher views and evaluates the video-taped student interviews based on the criteria listed in objective one.

HANDOUT:

Adelstein, M. E., & Davis, K. W. (1988). Business communication for the information age. Orlando: Harcourt Brace.

Unit Evaluation

The Job Search unit will be evaluated in a variety of ways by both teachers and students. Peer evaluation takes place while students prepare for the videotaped interview and complete job application forms. Teacher evaluation of student writing and role-playing is a second component of evaluation in the Job Search unit. A student who does not complete each lesson at a 70% proficiency should be remediated for that lesson. At the completion of the unit the entire unit is evaluated on the basis of the students' final project interview. The unit evaluation will include the content, objectives, and goals of the unit. Content evaluation includes oral and written communication and technical literature. Objective evaluation includes student competency in the (number) objectives of the unit as listed on the individual lesson plans. Goals include the final project job interview.

References

Adelstein, M. E., & Davis, K. W. (1988). Business communication for the information age. Orlando: Harcourt Brace.

Making and responding to requests. (1988). Applied communication, module 11. (pp. 17-26). Bloomington, IN: Agency for Instructional Technology.

Hagar, H.A., Stewart, M.M., & Hutchinson, L.E. (1953). Business English and letter writing. New York: McGraw-Hill.

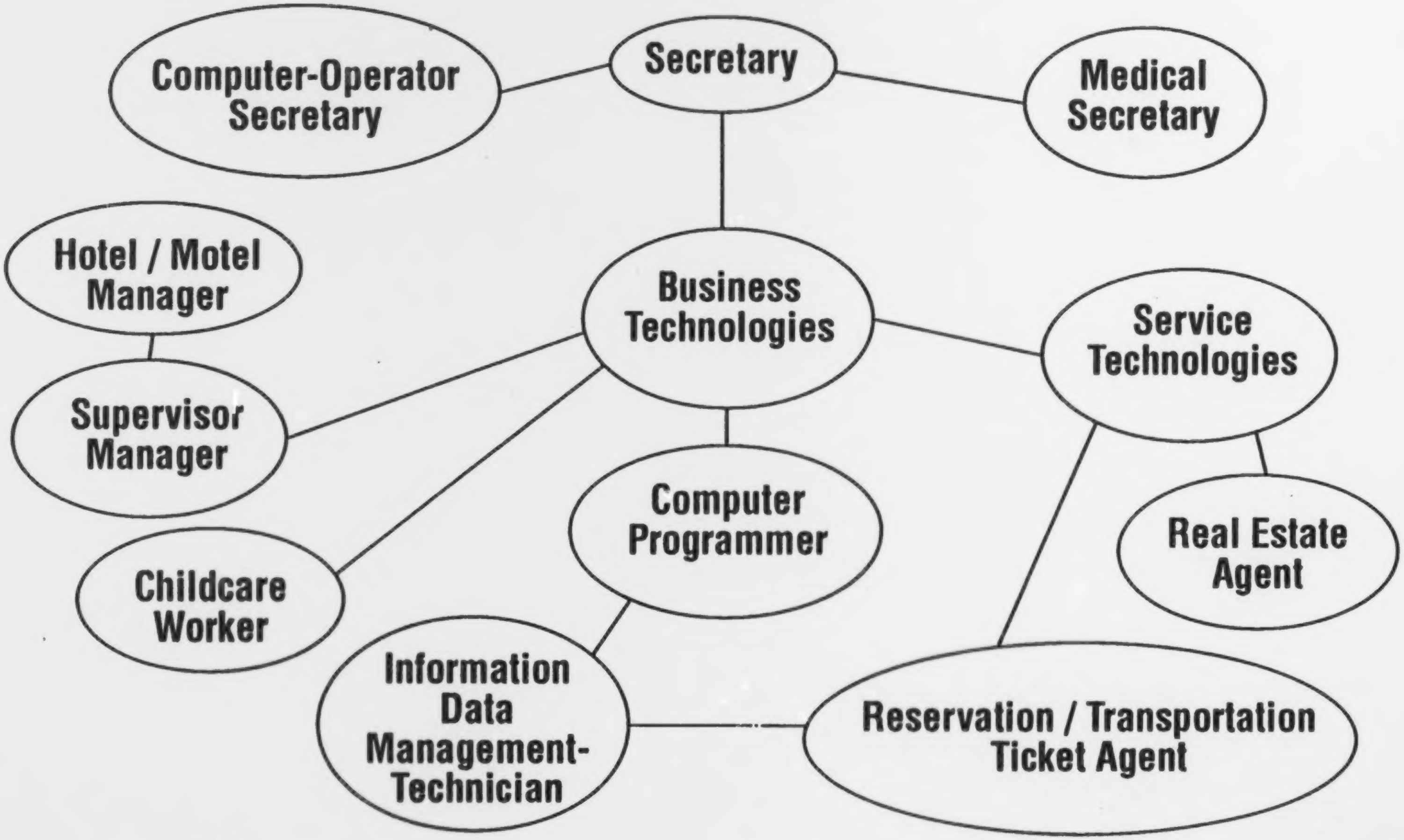
Language arts proficiency guide. (1991). Unpublished draft curriculum document. Indianapolis: Indiana Department of Education.

Macmillan English 12: Thinking and writing processes. (1988). New York: Scribner Laidlaw. (p. 241)

Secretary's Commission on Achieving Necessary Skills. (1991). What work requires of schools: A SCANS report for America 2000. Washington, DC: U.S. Department of Labor. (ERIC Document Reproduction Service No. ED 332 054)

Attachment 1
Cluster Search Method

Business Technologies Cluster


Computer-Operator Secretary
Secretary
Medical Secretary
Hotel / Motel Manager
Business Technologies
Service Technologies
Supervisor Manager
Computer Programmer
Real Estate Agent
Childcare Worker
Information Data Management-Technician
Reservation / Transportation Ticket Agent

TOWN & COUNTRY HOMECENTER

APPLICATION FOR EMPLOYMENT

(PRE-EMPLOYMENT QUESTIONNAIRE) (AN EQUAL OPPORTUNITY EMPLOYER)

PERSONAL INFORMATION

DATE

NAME (LAST / FIRST / MIDDLE) SOCIAL SECURITY NUMBER

PRESENT ADDRESS (STREET / CITY / STATE / ZIP)

PERMANENT ADDRESS (STREET / CITY / STATE / ZIP)

PHONE NO ARE YOU 18 YEARS OR OLDER? Yes ☐ No ☐

ARE YOU EITHER A U.S. CITIZEN OR AN ALIEN AUTHORIZED TO WORK IN THE UNITED STATES? Yes ☐ No ☐

EMPLOYMENT DESIRED

POSITION DATE YOU CAN START SALARY DESIRED

ARE YOU EMPLOYED NOW? IF SO MAY WE INQUIRE OF YOUR PRESENT EMPLOYER?

EVER APPLIED TO THIS COMPANY BEFORE? WHERE? WHEN?

REFERRED BY

EDUCATION	NAME AND LOCATION OF SCHOOL	*NO OF YEARS ATTENDED	*DID YOU GRADUATE?	SUBJECTS STUDIED
GRAMMAR SCHOOL				
HIGH SCHOOL				
COLLEGE				
TRADE, BUSINESS OR CORRESPONDENCE SCHOOL				

LAST

FIRST

MIDDLE

GENERAL

SUBJECTS OF SPECIAL STUDY OR RESEARCH WORK

SPECIAL SKILLS

ACTIVITIES: (CIVIC, ATHLETIC, ETC.)

EXCLUDE ORGANIZATIONS, THE NAME OF WHICH INDICATES THE RACE, CREED, SEX, AGE, MARITAL STATUS, COLOR OR NATION OF ORIGIN OF ITS MEMBERS

U.S. MILITARY OR NAVAL SERVICE RANK PRESENT MEMBERSHIP IN NATIONAL GUARD OR RESERVES

*The Age Discrimination in Employment Act of 1967 prohibits discrimination on the basis of age with respect to individuals who are at least 40 years of age

TOPS FORM 3285 (89-8) (CONTINUED ON OTHER SIDE) [illegible]

TOWN & COUNTRY HOMECENTER

FORMER EMPLOYERS (LIST BELOW LAST THREE EMPLOYERS, STARTING WITH LAST ONE FIRST).

DATE MONTH AND YEAR	NAME AND ADDRESS OF EMPLOYER	SALARY	POSITION	REASON FOR LEAVING
FROM				
TO				
FROM				
TO				
FROM				
TO				
FROM				
TO				

WHICH OF THESE JOBS DID YOU LIKE BEST?

WHAT DID YOU LIKE MOST ABOUT THIS JOB?

REFERENCES: GIVE THE NAMES OF THREE PERSONS NOT RELATED TO YOU, WHOM YOU HAVE KNOWN AT LEAST ONE YEAR.

NAME	ADDRESS	BUSINESS	YEARS ACQUAINTED
1			
2			
3			

THE FOLLOWING STATEMENT APPLIES IN: MARYLAND & MASSACHUSETTS. (Fill in name of state)
IT IS UNLAWFUL IN THE STATE OF ____________ TO REQUIRE OR ADMINISTER A LIE DETECTOR TEST AS A CONDITION OF EMPLOYMENT OR CONTINUED EMPLOYMENT. AN EMPLOYER WHO VIOLATES THIS LAW SHALL BE SUBJECT TO CRIMINAL PENALTIES AND CIVIL LIABILITY.

Signature of Applicant

IN CASE OF EMERGENCY NOTIFY
NAME ADDRESS PHONE NO.

"I CERTIFY THAT THE FACTS CONTAINED IN THIS APPLICATION ARE TRUE AND COMPLETE TO THE BEST OF MY KNOWLEDGE AND UNDERSTAND THAT, IF EMPLOYED, FALSIFIED STATEMENTS ON THIS APPLICATION SHALL BE GROUNDS FOR DISMISSAL.

I AUTHORIZE INVESTIGATION OF ALL STATEMENTS CONTAINED HEREIN AND THE REFERENCES LISTED ABOVE TO GIVE YOU ANY AND ALL INFORMATION CONCERNING MY PREVIOUS EMPLOYMENT AND ANY PERTINENT INFORMATION THEY MAY HAVE, AND RELEASE ALL PARTIES FROM ALL LIABILITY FOR ANY DAMAGE THAT MAY RESULT FROM FURNISHING SAME TO YOU.

I UNDERSTAND AND AGREE THAT, IF HIRED, MY EMPLOYMENT IS FOR NO DEFINITE PERIOD AND MAY, REGARDLESS OF THE DATE OF PAYMENT OF MY WAGES AND SALARY, BE TERMINATED AT ANY TIME WITHOUT PRIOR NOTICE AND WITHOUT CAUSE."

DATE SIGNATURE

DO NOT WRITE BELOW THIS LINE

INTERVIEWED BY DATE

REMARKS:

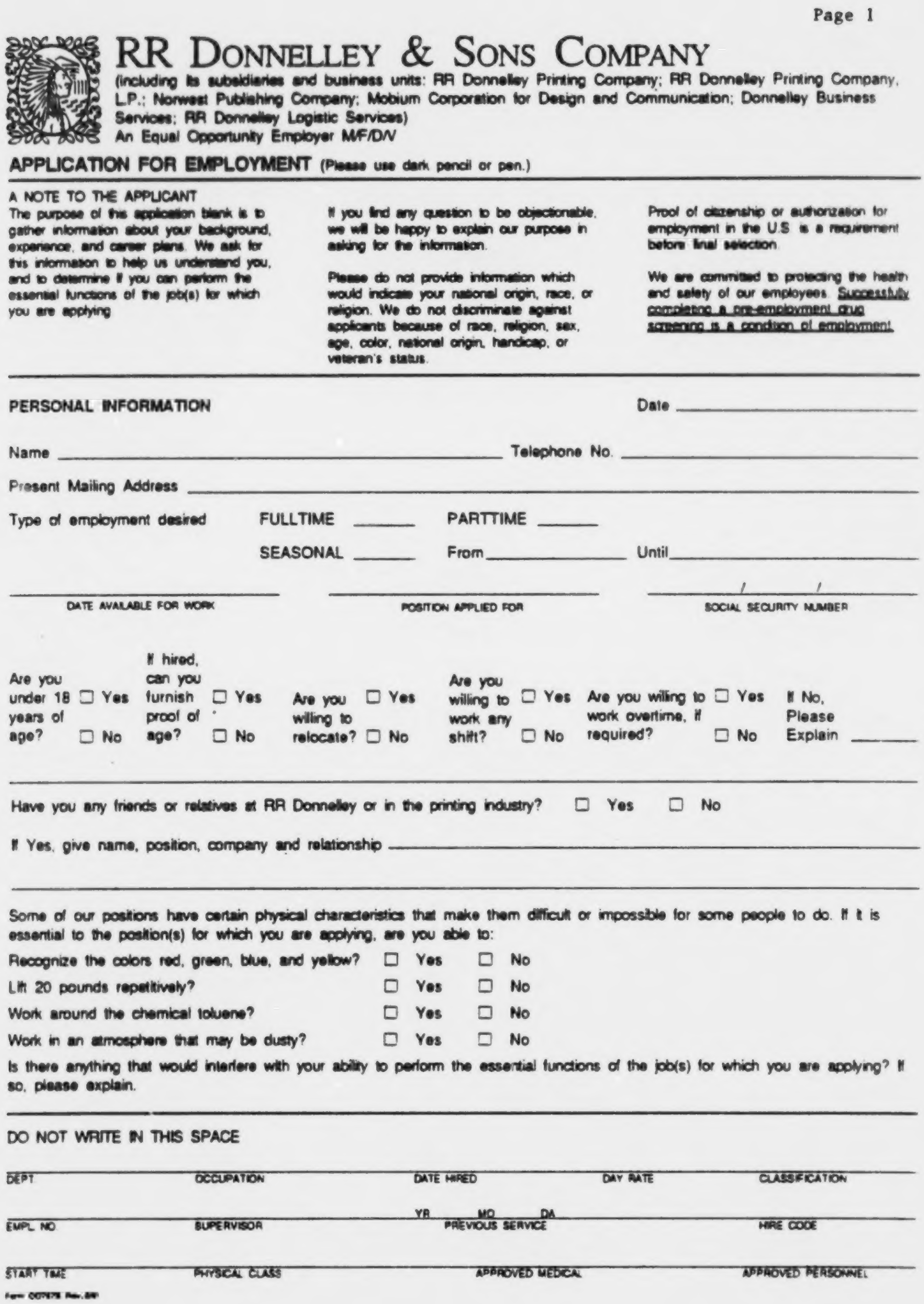
NEATNESS ABILITY

HIRED: ☐ Yes ☐ No POSITION DEPT.

SALARY/WAGE DATE REPORTING TO WORK

APPROVED: 1. EMPLOYMENT MANAGER 2. DEPT. HEAD 3. GENERAL MANAGER

This form has been designed to strictly comply with State and Federal fair employment practice laws prohibiting employment discrimination. This Application for Employment Form is sold for general use throughout the United States. TOPS assumes no responsibility for the inclusion in said form of any questions



RR DONNELLEY & SONS COMPANY

(including its subsidiaries and business units: RR Donnelley Printing Company; RR Donnelley Printing Company, L.P.; Norwest Publishing Company; Mobium Corporation for Design and Communication; Donnelley Business Services; RR Donnelley Logistic Services)
An Equal Opportunity Employer M/F/D/V

APPLICATION FOR EMPLOYMENT (Please use dark pencil or pen.)

A NOTE TO THE APPLICANT

The purpose of this application blank is to gather information about your background, experience, and career plans. We ask for this information to help us understand you, and to determine if you can perform the essential functions of the job(s) for which you are applying.

If you find any question to be objectionable, we will be happy to explain our purpose in asking for the information.

Please do not provide information which would indicate your national origin, race, or religion. We do not discriminate against applicants because of race, religion, sex, age, color, national origin, handicap, or veteran's status.

Proof of citizenship or authorization for employment in the U.S. is a requirement before final selection.

We are committed to protecting the health and safety of our employees. Successfully completing a pre-employment drug screening is a condition of employment.

PERSONAL INFORMATION

Date ______________________

Name ______________________ Telephone No. ______________________

Present Mailing Address ______________________

Type of employment desired FULLTIME ______ PARTTIME ______

SEASONAL ______ From ______________ Until ______________

______________________ DATE AVAILABLE FOR WORK

______________________ POSITION APPLIED FOR

_____ / _____ / _____ SOCIAL SECURITY NUMBER

Are you under 18 years of age? ☐ Yes ☐ No

If hired, can you furnish proof of age? ☐ Yes ☐ No

Are you willing to relocate? ☐ Yes ☐ No

Are you willing to work any shift? ☐ Yes ☐ No

Are you willing to work overtime, if required? ☐ Yes ☐ No

If No, Please Explain ______

Have you any friends or relatives at RR Donnelley or in the printing industry? ☐ Yes ☐ No

If Yes, give name, position, company and relationship ______________________

Some of our positions have certain physical characteristics that make them difficult or impossible for some people to do. If it is essential to the position(s) for which you are applying, are you able to:

Recognize the colors red, green, blue, and yellow? ☐ Yes ☐ No

Lift 20 pounds repetitively? ☐ Yes ☐ No

Work around the chemical toluene? ☐ Yes ☐ No

Work in an atmosphere that may be dusty? ☐ Yes ☐ No

Is there anything that would interfere with your ability to perform the essential functions of the job(s) for which you are applying? If so, please explain.

DO NOT WRITE IN THIS SPACE

DEPT

OCCUPATION

DATE HIRED

DAY RATE

CLASSIFICATION

YR MO DA

EMPL. NO

SUPERVISOR

PREVIOUS SERVICE

HIRE CODE

START TIME

PHYSICAL CLASS

APPROVED MEDICAL

APPROVED PERSONNEL

Form [illegible]

Have you ever applied for a position with RR Donnelley before? ☐ Yes ☐ No When?________ Where?________

Have you ever worked for RR Donnelley before? ☐ Yes ☐ No When?________ Where?________

Referred to RR Donnelley by ☐ Private Employment Agency ☐ Newspaper Ad ☐ College Recruiter

☐ State Employment Agency ☐ Self Referral ☐ RR Donnelley Employee ☐ Other________

MILITARY INFORMATION

Present Reserve Status (Include National Guard) ________

Have you served in any branch of the U.S. Armed forces? ☐ Yes ☐ No

Date entered on active duty ________ Date Released ________

In the past 5 years, have you ever been convicted of violating any laws other than minor traffic violations? ☐ Yes ☐ No

If Yes, state the nature of the offense, where, when, and disposition of the offense ________

EDUCATION

HIGH SCHOOL NAME AND LOCATION	FROM		TO		GRADUATED	
	MO.	YR.	MO.	YR.	YES	NO

If you did not graduate from high school, did you complete the G.E.D.? ☐ Yes ☐ No Date

							GRADUATED		
COLLEGE(S)	FROM		TO		MAJOR	MINOR	YES	NO	DEGREE
	MO.	YR.	MO.	YR.					
Other Schools (Specify)	MO.	YR.	MO.	YR.	Course Name		YES	NO	

WORK EXPERIENCE May we contact your present employer ☐ Yes ☐ No

Include Part Time – Begin with present or most recent employer – Use additional sheet if necessary.

Dates	Company's Name and Address	What Was Your Job?	Rate of Pay	Reason for Leaving
FROM				
TO				

Dates	Company's Name and Address	What Was Your Job?	Rate of Pay	Reason for Leaving
FROM				
TO				

Dates	Company's Name and Address	What Was Your Job?	Rate of Pay	Reason for Leaving
FROM				
TO				

I authorize RR Donnelley & Sons Company to contact the personal references sources provided above and to make a thorough investigation of my past employment and activities, agree to cooperate in such investigation, and release from all liability or responsibility all persons and corporations requesting or supplying such information.

I certify that all information requested on this application is correct and understand that I shall be subject to discharge for false information or failure to provide material information requested.

This application does not create an offer of employment. If I become employed by RR Donnelley & Sons Company, I understand that my employment can be terminated at any time by either myself or the company.

____

Signature (Sign-DO NOT PRINT)

MODULE 1: LANGUAGE ARTS

UNIT 2

CREATE-A-PRODUCT

by

James E. Green
Ball State University

Kathy Little
Columbus East High School

Abstract

This unit involves collaboration between language arts and technology teachers. Students work in groups to develop, design, and produce a product. Units that involve collaboration with teachers of science, mathematics, or other disciplines could be developed along similar lines.

Indiana Tech Prep Training Materials: Division II
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

CREATE-A-PRODUCT

Introduction

In the job market of today, employers consistently demand competence in several areas, regardless of the career. First they require competence in basic skills, including the traditional language arts. They expect competence in using technology. And, they expect competence in "teamwork" skills--being able to work effectively with others to solve problems or reach goals. These expectations suggest a new way of integrating language skills into the world of technology. Students need to be able to see the connection between what they are learning in the language arts and what they will be expected to know when they enter the job market. This unit demonstrates to students that language and group problem solving skills are used in every phase of the business of creating a product and producing it.

This unit, "Create-A-Product," was developed for high school juniors of average ability. Most of the students expect to work toward an associate degree after high school and seek employment in the community. Most of the students presently have jobs, and they generally have a preference for instruction that is "hands on."

The school where "Create-A-Product" has been successfully taught has approximately 1250 students representing the full range of socio-economic conditions found in the community. The school is the second high school in the community, and it works hard to create its own identity. The school was conceived as an innovative institution using small-group/large-group scheduling for which classrooms were designed. Changes in philosophy have moved the school toward more traditional scheduling. Yet the school maintains the philosophy of providing a wide choice of subjects within an eight period day.

The level of commitment to Tech Prep is high in the school. There are presently classes in math, electro physics, medical biology, computer power, and junior and senior communications (English). In each instance, the curriculum was written by interdisciplinary teams who share the responsibility for the classes. The administration has been able to schedule some time for interdisciplinary planning, and the counselors are helpful in advising students into Tech Prep who would most benefit.

The business community has shown enthusiastic support for Tech Prep as demonstrated by their willingness to provide speakers and to invite classes to visit their factories and businesses. They also provide internships for the faculty in the summer. A committee of business leaders assists with curriculum development.

The technological resources available to students are twenty IBM compatible computers and three Macintosh computers. The software consists of MicroSoft Works, Grammatic, various art programs, AutoCad, Math Cad and PFS 1st Choice. The students use a Macintosh computer to design ads. A Rhino robot and Emco Meir CNC lathe may be used to manufacture the students' product.

Unit Overview

"Create-A-Product" is designed to integrate technology and English by engaging students in a group project which demonstrates the steps of bringing an idea to a final product. The unit is designed for team teaching by an English teacher and a technology teacher. Group problem solving skills lead the list of concepts to be included. Working cooperatively to complete a task is a skill that our business people have stressed as being important in today's work place. Technical/descriptive writing, media writing, and researching for a market analysis are also important concepts included in the unit. The unit requires the use of technology to complete various tasks, since the product must be produced in the automated lab. In addition, the design and marketing of the product requires the use of software such as CAD and PageMaker. It is assumed that students are familiar with the software from previous Tech Prep classes. The students make decisions regarding the best technology to use for their project. Finally, presenting the product to an outside audience of actual business customers concludes the unit.

General Objectives

General objectives for language arts units are discussed in Unit 1 of this module, and a three dimensional structure for language arts objectives is depicted in Figure 1 of Unit 1. The objectives that comprise two dimensions of that three dimensional structure are shown in Figures 2, 3, and 4 of Unit 1. Those two dimensions are the same for Unit 1, "The Personal Job Search", and this unit, "Create-A-Product." The third dimension, the specific unit objectives, are not the same. Figure 1 lists the unit objectives for this unit, and Figures 2, 3, and 4 provide a matrix which correlates the unit objectives with general Tech Prep objectives (Figures 2 and 3) and state language arts proficiencies (Figure 4).

The objectives for the unit are listed in a matrix format so that it is plain how the unit objectives integrate with general Tech Prep goals and state language arts proficiencies. Teachers who plan to develop their own Tech Prep units might be assisted by using this same format in order to insure consideration of some of the overarching principles of Tech Prep at the basic stage of instructional planning.

Figure 1

"Create-A-Product" Unit Objectives

Upon successful completion of "Create-A-Product" students will be able to:

1. Learn rules for group activities.
2. Participate effectively in group bonding activities.
3. Determine whether it is possible to produce a product in the automated lab.
3. Use the group process to develop a product idea.
4. Describe in detail (including dimensions) the table or desk at which they are seated and tell how the seat is assembled.
5. As a group, combine their descriptions into one document.
6. As a group, create a company name and letterhead.
7. Describe a product accurately with dimensions, specifications, parts list, and assemble instructions.
8. Draw the specifications of a product on the CAD.
9. Produce a list of parts in order to develop a unit cost.
10. Develop a flow chart showing the steps in manufacturing a product.
11. Identify characteristics of the consumer who will buy a product.
12. Determine which advertising medium would best reach their buyers.
13. Develop a questionnaire to test the market for a product.
14. Create a chart to illustrate the results of market research.
15. Identify basic appeals and unique selling propositions (memorable slogans) in advertising.
16. Apply knowledge of basic appeals and unique selling propositions (memorable slogans) in creating advertising media.
17. Create a magazine ad using knowledge of basic appeals and unique selling propositions.
18. Demonstrate layout principles for a magazine ad.
19. Produce the product under the supervision of a technology teacher.
20. Compile all of the revised assignments in the project into one package to present to the class and to the teacher for final evaluation.
21. Conduct a sales presentation for a completed product to an audience of professionals.

Figure 2
Tech Prep Goals (Foundations) and Unit Objectives

Unit Objectives	Basic Skills: Reading	Basic Skills: Writing	Basic Skills: Math	Basic Skills: Listening	Basic Skills: Speaking	Thinking Skills: Creative Thinking	Thinking Skills: Decision Making	Thinking Skills: Problem Solving	Thinking Skills: Processing	Thinking Skills: Learning to Learn	Thinking Skills: Reasoning	Personal Qualities: Responsibility	Personal Qualities: Self-esteem	Personal Qualities: Sociability	Personal Qualities: Self-management	Personal Qualities: Integrity/Honesty
Learn rules for group activities.							✓					✓		✓	✓	✓
Participate effectively in group bonding activities.				✓								✓	✓	✓	✓	✓
Determine whether it is possible to produce a product in the automated lab.	✓						✓	✓		✓	✓	✓			✓	
Use the group process to develop a product idea.		✓		✓		✓								✓	✓	
Describe in detail (including dimensions) the table or desk at which they are seated and tell how the seat is assembled.		✓		✓					✓						✓	
As a group, combine their descriptions into one document.		✓							✓			✓			✓	
As a group, create a company name and letterhead.						✓	✓						✓		✓	
Describe a product accurately with the dimensions, specifications, parts list, and assemble instructions.		✓	✓						✓						✓	

Tech Prep Goals

Figure 2
Tech Prep Goals (Foundations) and Unit Objectives

Unit Objectives	Tech Prep Goals															
	Basic Skills: Reading	Basic Skills: Writing	Basic Skills: Math	Basic Skills: Listening	Basic Skills: Speaking	Thinking Skills: Creative Thinking	Thinking Skills: Decision Making	Thinking Skills: Problem Solving	Thinking Skills: Processing	Thinking Skills: Learning to Learn	Thinking Skills: Reasoning	Personal Qualities: Responsibility	Personal Qualities: Self-esteem	Personal Qualities: Sociability	Personal Qualities: Self-management	Personal Qualities: Integrity/Honesty
Draw the specifications of a product using CAD.	✓		✓			✓		✓	✓		✓	✓			✓	
Produce a list of parts in order to develop a unit cost.			✓					✓	✓		✓	✓			✓	
Develop a flow chart showing the steps in manufacturing a product.									✓		✓	✓			✓	
Identify characteristics of the consumer who will buy a product.	✓					✓						✓			✓	
Determine which advertising medium would best reach their buyers.	✓					✓						✓			✓	✓
Develop a questionaire to test the market for a product.	✓	✓					✓	✓				✓			✓	✓
Create a chart to illustrate the results of market research.									✓		✓	✓			✓	
Identify basic appeals and unique selling propositions (memorable slogans) in advertising.	✓	✓		✓		✓	✓				✓	✓			✓	✓

Figure 2
Tech Prep Goals (Foundations) and Unit Objectives

Unit Objectives	Basic Skills: Reading	Basic Skills: Writing	Basic Skills: Math	Basic Skills: Listening	Basic Skills: Speaking	Thinking Skills: Creative Thinking	Thinking Skills: Decision Making	Thinking Skills: Problem Solving	Thinking Skills: Processing	Thinking Skills: Learning to Learn	Thinking Skills: Reasoning	Personal Qualities: Responsibility	Personal Qualities: Self-esteem	Personal Qualities: Sociability	Personal Qualities: Self-management	Personal Qualities: Integrity/Honesty
Apply knowledge of basic appeals and unique selling propositions (memorable slogans) in creating advertising media.	✓	✓		✓		✓	✓		✓		✓	✓			✓	✓
Create a magazine ad using knowledge of basic appeals and unique selling propositions.	✓	✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Demonstrate layout principles for magazine ad.						✓		✓				✓			✓	
Produce the product under the supervision of a technology teacher.								✓				✓	✓	✓	✓	
Compile all of the revised assignments in the project into one package to present to the class and to the teacher for final evaluation.	✓	✓							✓			✓	✓	✓	✓	✓
Conduct a sales presentation for a completed product to an audience of professionals.	✓	✓		✓	✓	✓						✓	✓	✓	✓	✓

Figure 3
Tech Prep Goals (Competencies) and Unit Objectives

Unit Objectives	Utilizes Time	Utilizes Money	Utilizes Materials and Facilities	Utilizes Human Resources	Participates as a Team Member	Teaches Others Skills	Serves Clients/Customers	Exercises Leadership	Negotiates	Works with Diversity	Acquires and Evaluates Information	Organizes and Maintains Information	Interprets and Communicates Information	Uses Computers to Process Information	Understands Systems	Monitors and Corrects Performance	Improves or Designs Systems	Selects Technology	Applies Technology	Maintains and Troubleshoots Equipment
Learn rules for group activities.	✓			✓	✓															
Participate effectively in group bonding activities.				✓	✓				✓											
Determine whether it is possible to produce a product in the automated lab.	✓				✓						✓				✓					
Use the group process to develop a product idea.	✓			✓	✓			✓	✓				✓							
Describe in detail (including dimensions) the table or desk at which they are seated and tell how the seat is assembled.					✓								✓							
As a group, combine their descriptions into one document.					✓								✓							
As a group, create a company name and letterhead.					✓															
Describe a product accurately with the dimensions, specifications, parts list, and assemble instructions.					✓								✓							

Figure 3
Tech Prep Goals (Competencies) and Unit Objectives

Unit Objectives	Utilizes Time	Utilizes Money	Utilizes Materials and Facilities	Utilizes Human Resources	Participates as a Team Member	Teaches Others Skills	Serves Clients/Customers	Exercises Leadership	Negotiates	Works with Diversity	Acquires and Evaluates Information	Organizes and Maintains Information	Interprets and Communicates Information	Uses Computers to Process Information	Understands Systems	Monitors and Corrects Performance	Improves or Designs Systems	Selects Technology	Applies Technology	Maintains and Troubleshoots Equipment
Draw the specifications of a product using CAD.					✔								✔	✔		✔			✔	
Produce a list of parts in order to develop a unit cost.		✔	✔		✔						✔	✔				✔				
Develop a flow chart showing the steps in manufacturing a product.	✔				✔						✔		✔		✔	✔	✔			
Identify characteristics of the consumer who will buy a product.					✔		✔			✔										
Determine which advertising medium would best reach their buyers.		✔			✔		✔			✔			✔							
Develop a questionaire to test the market for a product.					✔		✔			✔	✔			✔					✔	
Create a chart to illustrate the results of market research.					✔		✔				✔	✔		✔					✔	
Identify basic appeals and unique selling propositions (memorable slogans) in advertising.					✔		✔			✔										

Figure 3
Tech Prep Goals (Competencies) and Unit Objectives

Unit Objectives / Tech Prep Goals	Utilizes Time	Utilizes Money	Utilizes Materials and Facilities	Utilizes Human Resources	Participates as a Team Member	Teaches Others Skills	Serves Clients/Customers	Exercises Leadership	Negotiates	Works with Diversity	Acquires and Evaluates Information	Organizes and Maintains Information	Interprets and Communicates Information	Uses Computers to Process Information	Understands Systems	Monitors and Corrects Performance	Improves or Designs Systems	Selects Technology	Applies Technology	Maintains and Troubleshoots Equipment
Apply knowledge of basic appeals and unique selling propositions (memorable slogans) in creating advertising media.					✓		✓			✓			✓							
Create a magazine ad using knowledge of basic appeals and unique selling propositions.					✓					✓			✓							
Demonstrate layout principles for magazine ad.					✓									✓					✓	
Produce the product under the supervision of a technology teacher.	✓	✓	✓		✓										✓	✓	✓	✓	✓	✓
Compile all of the revised assignments in the project into one package to present to the class and to the teacher for final evaluation.					✓											✓				
Conduct a sales presentation for a completed product to an audience of professionals.					✓		✓	✓		✓			✓						✓	

Figure 4
Language Arts Proficiencies and Unit Objectives

Unit Objectives \ Language Arts Proficiencies	Exhibit a positive attitude toward language and learning...	Use developmentally appropriate materials to select and apply effective straetgies for reading...	Comprehend developmentally appropriate materials...	Select and use developmentally appropriate strategies for writing...	Write for different audiences and purposes using a variety of forms...	Use prior knowledge and subject area information to make critical judgements...	Communicate orally and in writing...	Recognize inter-relatedness of language, literature, and culture...
Learn rules for group activities.								
Participate effectively in group bonding activities.								
Determine whether it is possible to produce a product in the automated lab.		✓	✓			✓		
Use the group process to develop a product idea.								
Describe in detail (including dimensions) the table or desk at which they are seated and tell how the seat is assembled.					✓		✓	
As a group, combine their descriptions into one document.					✓		✓	
As a group, create a company name and letterhead.								
Describe a product accurately with the dimensions, specifications, parts list, and assemble instructions.					✓		✓	

Figure 4
Language Arts Proficiencies and Unit Objectives

Unit Objectives \ Language Arts Proficiencies	Exhibit a positive attitude toward language and learning...	Use developmentally appropriate materials to select and apply effective strategies for reading...	Comprehend developmentally appropriate materials...	Select and use developmentally appropriate strategies for writing...	Write for different audiences and purposes using a variety of forms...	Use prior knowledge and subject area information to make critical judgements...	Communicate orally and in writing...	Recognize inter-relatedness of language, literature, and culture...
Draw the specifications of a product using CAD.								
Produce a list of parts in order to develop a unit cost.								
Develop a flow chart showing the steps in manufacturing a product.								
Identify characteristics of the consumer who will buy a product.								
Determine which advertising medium would best reach their buyers.								
Develop a questionaire to test the market for a product.					✓		✓	
Create a chart to illustrate the results of market research.								
Identify basic appeals and unique selling propositions (memorable slogans) in advertising.				✓	✓		✓	

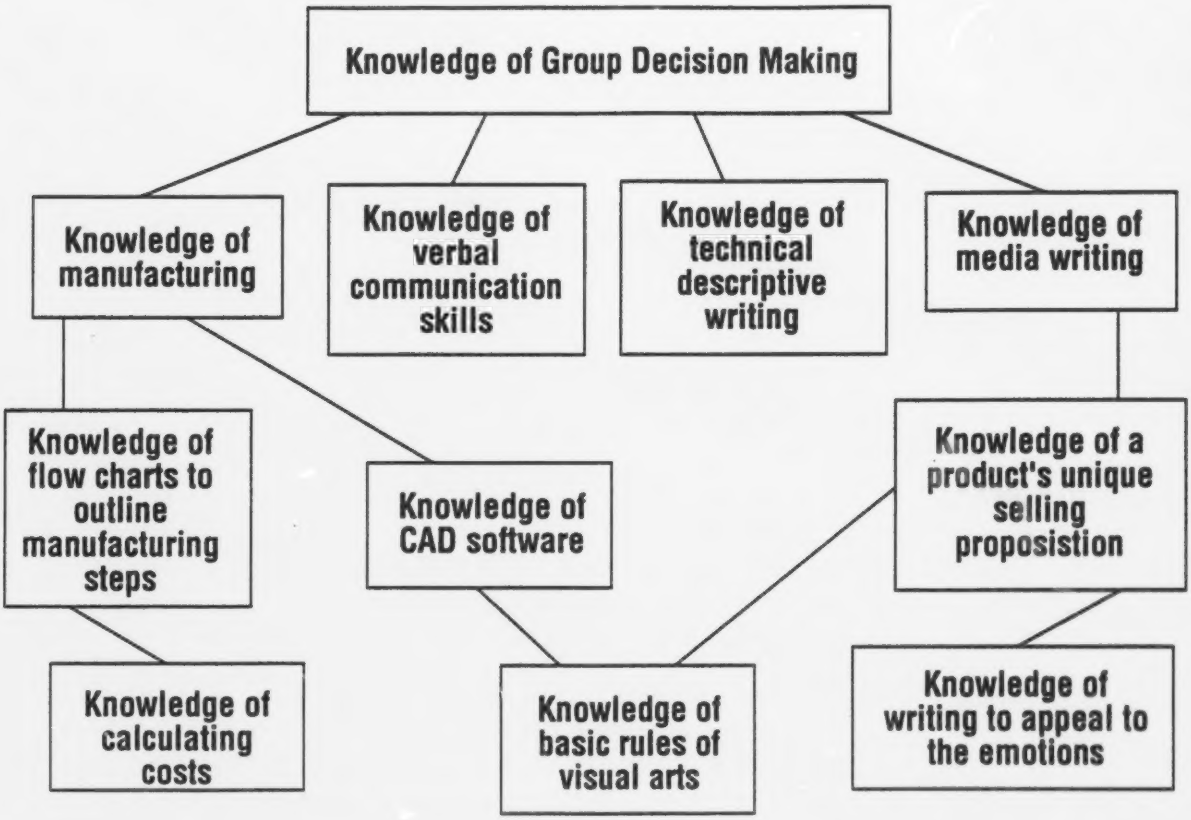
Figure 4
Language Arts Proficiencies and Unit Objectives

Unit Objectives \ Language Arts Proficiencies	Exhibit a positive attitude toward language and learning...	Use developmentally appropriate materials to select and apply effective strategies for reading...	Comprehend developmentally appropriate materials...	Select and use developmentally appropriate strategies for writing...	Write for different audiences and purposes using a variety of forms...	Use prior knowledge and subject area information to make critical judgements...	Communicate orally and in writing...	Recognize inter-relatedness of language, literature, and culture...
Apply knowledge of basic appeals and unique selling propositions (memorable slogans) in creating advertising media.	✓			✓	✓	✓	✓	
Create a magazine ad using knowledge of basic appeals and unique selling propositions.	✓			✓	✓	✓	✓	
Demonstrate layout principles for magazine ad.							✓	
Produce the product under the supervision of a technology teacher.								
Compile all of the revised assignments in the project into one package to present to the class and to the teacher for final evaluation.						✓		
Conduct a sales presentation for a completed product to an audience of professionals.	✓			✓	✓	✓	✓	

Outline for Unit Content

The outline of content for "Create-A-Product" is presented in a conceptual framework in Figure 5. The overriding concept is group decision making under which all the content of the unit is organized.

Figure 5
Conceptual Framework for Create-A-Product


Knowledge of Group Decision Making
Knowledge of manufacturing
Knowledge of verbal communication skills
Knowledge of technical descriptive writing
Knowledge of media writing
Knowledge of flow charts to outline manufacturing steps
Knowledge of CAD software
Knowledge of a product's unique selling proposistion
Knowledge of calculating costs
Knowledge of basic rules of visual arts
Knowledge of writing to appeal to the emotions

Instructional Strategies

The outline of instructional strategies is presented in a matrix that depicts the characteristic Tech Prep strategies and the unit planned instructional activities. Strategies and instructional activities are presented in this form so that an English teacher can use the same kind of format when planning a different unit. The key is monitoring the extent to which the unit's instructional activities reflect the strategies that are essential to Tech Prep.

Tech Prep Strategies

I. Alternative Learning Styles
II. Cooperative Learning
III. Problem Solving
IV. Applications Based Instruction

Unit Activities

1. Brainstorming a product idea
2. Researching the resources needed to produce product
3. Researching governmental and environmental regulations
4. Writing a technical description
5. Creating letterhead templates
6. Drawing dimensions on CAD
7. Identifying the consumer
8. Conducting a market survey
9. Calculating cost
10. Purchasing materials
11. Creating a flow chart
12. Producing a product
13. Determining packaging
14. Determine sales outlet
15. Determining appropriate media for ad
16. Writing ad copy
17. Planning ad layout
18. Writing radio script
19. Planning T.V. story board
20. Creating a visual display
21. Present product orally

Figure 6
Unit Activities and Instructional Strategies

Unit Activities	Alternative Learning Styles	Cooperative Learning	Problem Solving	Applications Based Instruction
Brainstorming a product idea.	✓	✓	✓	✓
Researching the resources needed to produce product.		✓		✓
Researching governmental and environmental regulations.				✓
Writing a technical description.		✓		✓
Creating letterhead templates.	✓	✓		✓
Drawing dimensions on CAD.	✓		✓	✓
Identifying the consumer.		✓		✓
Conducting a market survey.		✓	✓	✓
Calculating cost.			✓	✓
Purchasing materials.		✓		✓
Creating a flow chart.	✓	✓	✓	✓
Producing a product.	✓	✓	✓	✓
Determining packaging.	✓		✓	✓
Determine sales outlet.		✓	✓	✓

Figure 6
Unit Activities and Instructional Strategies

Unit Activities	Alternative Learning Styles	Cooperative Learning	Problem Solving	Applications Based Instruction
Determing appropriate media for adveritsement.	✓	✓	✓	✓
Writing ad copy.		✓		✓
Planning ad layout.	✓	✓	✓	✓
Writing radio script.	✓	✓		✓
Planning T.V. story board.	✓	✓		✓
Creating a visual display.	✓	✓	✓	✓
Present product orally.	✓	✓		✓

LESSON ONE
GROUP FORMATION AND BRAINSTORMING
(2-3 DAYS)

OBJECTIVES:

Students will be able to:

1. Learn rules for group activities.
2. Learn what projects are possible to produce in the automated lab.
3. Use the group process to decide a product idea.

ACTIVITIES:

1. Teacher will introduce the groups and distribute the rules for group activities. The rules state that the group must sign the sign-off slip for each assignment attesting to the fact that they have contributed thought and time to the completion of the assignment. (See Attachment 1 and Attachment 2)
2. The teacher gives out folders to each group in which all assignments and completed work will be kept. The folders remain in the classroom at all times.
3. Student groups will complete a shield reflecting their interests and goals. (See Attachment 3)
4. Student groups will tell their life story to each other in 30 seconds.
5. Students will visit the automated lab with the technology teacher to learn the kinds of items that can be produced.
6. Groups will brainstorm a product idea.

EVALUATION:

1. Groups are given the full amount of points for deciding on an idea in the time allotted.

   Note: The teacher decides the groups by assessing each individual's strengths and weaknesses with the help of a survey given before the unit begins. (See Attachment 4)

LESSON TWO
WARMUP FOR PRODUCT DESCRIPTION
(3 DAYS)

OBJECTIVES:

Students will be able to:

1. Describe in detail (including dimensions) the table or desk at which they are seated and tell how the seat is assembled.
2. As a group, combine their descriptions into one document.

ACTIVITIES:

1. Individual students will write a detailed description (including dimensions) of the table or desk at which they are seated and tell how the seat is assembled. (See Attachment 5.)
2. Individual students should be able to list all the individual parts at the end of their description.
3. As a group, students should blend each other's description into one document using the word processor for their final product.
4. The groups will turn in the final paper and include the individual descriptions.
5. Each group member will sign the sign-off sheet indicating that each has contributed to the final product.

EVALUATION:

1. The teacher will proof-read and make recommendations for improvement.
2. The full amount of points will be assigned to the group upon completion of the revision.

Note: From this point on, members of the group will continue progress of the project independently of one another. The group divides the tasks to be completed. They must still sign off each assignment.

LESSON THREE
COMPANY NAME, LETTER HEAD AND LOGO
(1 DAY)

OBJECTIVES:

Students will be able to:

1. As a group, create a company name and letterhead.

ACTIVITIES:

1. Groups will brainstorm a company name, letter head and logo. (See Attachment 6)
2. Using a CAD or Macintosh PageMaker, groups will create a letterhead and logo to be used on all future assignments.
3. The teacher will duplicate pages with the company name, letter head and logo. The pages are then to be used for all assignments.
4. The members of the group will sign the sign-off slip to indicate that they have contributed to the completion of the assignment.

EVALUATION:

1. Groups are given the full amount of points upon completing the assignment.

LESSON FOUR
PRODUCT DESCRIPTION
(1 DAY)

OBJECTIVES:

Students will be able to:

1. As a group, describe their product accurately with dimensions and a listing of all parts as well as how it is put together.

ACTIVITIES:

1. As a group, the students will write a technical description of their product including dimensions and number of parts required as well as how the product is to be assembled.
2. The members of the group will sign the sign-off slip to indicate that they have contributed to the completion of the assignment.

EVALUATION:

1. Groups will receive the full amount of points upon completion of revisions suggested by the teacher.

Note: An additional activity might be to research governmental or environmental regulations affecting their product.

LESSON FIVE
TECHNICAL DRAWING OF SPECIFICATIONS AND MANUFACTURING STEPS
(2-3 DAYS)

OBJECTIVES:

1. Students are to draw the specifications of their product on the CAD (a drafting software).
2. Students are to produce a list of parts in order to develop a unit cost.
3. Students are to develop a flow chart showing the steps in manufacturing their product.

ACTIVITIES:

1. Students will assign tasks within their groups to complete the assignment.
2. Students will draw on the CAD the product with the dimensions.
3. Students will call suppliers in the community to determine the unit cost of their product.
4. Students will consult with the technology teacher about the steps of production and create a flow chart showing those steps. (see Attachment 7)
5. Students will use their company letter head on the drawing, cost sheet and flow chart. (See Attachment 8)
6. Members of the group will sign the sign-off slip to show that they have contributed to or have been consulted about each of the above assignments.

EVALUATION:

1. Groups will receive the full amount of points upon the completion of revisions suggested by the teachers.

   Note: An additional activity might be to secure the materials needed to produce the product from community sources if the school does not already have what is needed. Community businesses might be willing to donate materials.

LESSON SIX
MARKET ANALYSIS
(2-3 DAYS)

OBJECTIVES:

Students will be able to:

1. Identify the kind of consumer who will want their product.
2. Determine which advertising medium would best target their consumer.
3. Develop a questionnaire to test the market for their product.
4. Create a chart to show the findings of their questionnaire.

ACTIVITIES:

1. The students will write a description of the consumer who is likely to buy their product and which advertising medium would best target their audience. (See Attachment 9)
2. The students will create a short questionnaire to test the market for their product. They can give the questionnaire to their other classes.
3. The students will make a chart which shows the results of their findings.
4. Members of the group will sign the sign-off slip to show that they have contributed to or have been consulted about each of the above assignments.

EVALUATION:

1. Groups will receive the full amount of points upon completion of revisions suggested by the teacher.

LESSON SEVEN
PLANNING AN ADVERTISING CAMPAIGN
(4-5 DAYS)

OBJECTIVES:

Students will be able to:

1. Identify basic appeals and unique selling propositions (memorable slogans) in advertising.
2. Apply knowledge of basic appeals and unique selling propositions (memorable slogans) in creating advertising for their product.

ACTIVITIES:

1. Teacher distributes handout detailing the basic appeals and unique selling propositions (memorable slogans). (See Attachment 10)

2. Using overhead projector, teacher presents examples of basic appeals and slogans used in magazine advertising. (Teacher needs to collect examples from magazines and newspapers and make transparencies.)

3. Students to go to the library to search for ads which will represent the basic appeals and unique selling proposition (slogans). (See Attachment 11) The librarian may have old magazines which the students can use to cut out the ads, or they may be able to duplicate copies of the ads. The group divides the task among themselves and completes the task in one class period.

4. During the next class period, the students share their findings with the class.

EVALUATION:

1. The teacher checks to see if all appeals are represented and gives the full amount of points.

LESSON EIGHT
CREATING A MAGAZINE AD
(3-4 DAYS)

OBJECTIVES:

Students will be able to:

1. Create a magazine ad using their knowledge of basic appeals and unique selling propositions.
2. Utilize standard layout rules in their magazine ad.

ACTIVITIES:

1. The teacher will present the standard layout rules. (See Attachment 12)
2. The groups will brainstorm ad ideas using what they have learned about basic appeals and unique selling propositions.
3. Utilizing the standard layout rules, the groups will draw a sample layout which shows the placement of copy, headline, a visual, a slogan, a company logo and the company address. The teacher will make suggestions for revisions.
4. The students will produce an ad which includes copy, headline, a visual, a slogan, company logo and company address on poster board.

EVALUATION:

1. The teacher will award points based upon the inclusion of all of the elements requested in the assignment.

   Note: Depending on the facilities, groups could choose television or radio advertising or T-shirt advertising.

LESSON NINE
PRODUCING THE PRODUCT
(OVER THE PERIOD OF THE PROJECT)

OBJECTIVES:

Students will be able to:

1. Produce the product with the help of the technology teacher.

ACTIVITIES:

1. During the course of the project students within the groups will work with the technology teacher to produce the product in the industrial lab.

EVALUATION:

1. The full amount of points is awarded upon completion of the product.

Note: Additional activities could be to design packaging and determine the best sales outlet for the product.

LESSON TEN
FINAL PRESENTATION

OBJECTIVES:

Students will be able to:

1. Compile all of the revised assignments in the project into one package to present to the class and to the teacher for final evaluation.
2. Students will orally present their project to an outside audience of business clients or customers.

ACTIVITIES:

1. The groups will print out all assignments (except the library assignment) on paper with the company letterhead and logo.
2. The groups will design a cover sheet with the name of the company, members' names and date.
3. The groups will prepare an oral presentation of their product to an outside audience of adults.

EVALUATION:

1. The teacher will subjectively evaluate the group's ability to compile all the elements of the project into one document. The teacher will also assign a portion of the points to individuals based upon their group problem solving skills. The full amount of points will be awarded for the oral presentation.
2. The group also evaluates itself using the Group Evaluation Questionnaire. (See Attachment 13)

   Note: Other culminating activities might include a trade show in a mall setting, presenting the product to an investor or banker, or presenting the product to a patent lawyer.

Unit Evaluation

The teacher evaluation of the students is twofold: individual and group. The individual evaluation is aided by the sign-off slips which accompany each assignment and by the teacher's subjective observations. The group evaluation is determined by how promptly deadlines are met and by the quality of the final product. The two evaluations count equally and an average of the two determine the students' grade.

The success of the unit is measured by how well students are able to use the group process to produce a product and by their perception of the unit value as discovered through the questionnaire. Often students will have constructive comments about ways to improve activities. It is also necessary to have each student evaluate the group process itself via a form which maintains anonymity of individual members.

Unit Resources

The technological resources needed are IBM compatible computers and/or Macintosh computers. The software consists of MicroSoft Works, Grammatic, various art programs (*e.g.*, Superpaint Clip Art, etc.), AutoCad, Math Cad and PFS 1st Choice. The students will use a Macintosh computer to design ads. A Rhino robot and Emco Meir CNC lathe may be used to manufacture the students' products.

The businesses in the community may be willing to supply some raw materials for the projects.

Attachment 1

RULES FOR GROUP WORK

1. All work in progress, completed and graded work should be placed in the group folder and kept in the classroom. (Each group should devise a check list to keep track of assignments, due dates and dates the assignments were turned in).
2. Place all handouts in folder.
3. Know each other's phone number in case a member is absent.
4. Be responsible for informing a group member who has been absent about what has gone on in class. Give that person all handouts given on the day of absence.
5. Each assignment will include a sign-off form to be signed by each member. If one member did not contribute to the assignment in any way, then that person should not sign the form.
6. Try on your own to solve any group problems that arise. If one person is not contributing, it may be because he/she has not been given a chance. Stress cooperation among yourselves.

Attachment 2

COMPLETE ASSIGNMENT
SIGN OFF FORM

The members of group ________________ have contributed thought and time to completing the attached assignment.

____

____

____

Attachment 3

Personal Shield

Name________________________

Life Status	Accomplishments
Compliments	What I Do for Fun
Happiest Time of My Life	One Word to Describe Myself
Limitations Today	Hopes for Tomorrow

Attachment 4

SURVEY QUESTIONS FOR GROUP ACTIVITIES

On a scale of 1-10 rate the following statements:

1	2	3	4	5	6	7	8	9	10
No									Yes

____ 1. When I write, I find that ideas come to me fairly easily.

____ 2. More ideas come to me when I am with a group of students.

____ 3. On a scale of one to ten, with ten being the highest, rate your typing skills.

____ 4. When working in groups, I prefer to record the activities being performed by my group.

____ 5. When working in groups, I prefer to report orally the activities being performed by my group.

____ 6. I enjoy investigating how something I am interested in works.

____ 7. I am the type of person who starts working on an assignment as soon as it is assigned.

____ 8. I feel that when working in a group situation, I am open to suggestions from others.

____ 9. I feel that my mechanical skills are greater than my writing skills.

____10. My computer skills are good, and I am able to figure out new software fairly easily.

____11. I enjoy drawing and designing.

____12. I have good chart making skills.

Attachment 5

PRODUCT DESCRIPTION

Each member of the group should describe in detail the table at which they are sitting. The description should include an accurate description of the dimensions and each individual part of the table as well as how it is put together. At the end of the description, list all the individual parts of the table.

- As a group, blend each other's description into one document using the word processor for your final product. Submit a rough draft to me for any corrections and suggestions.
- Turn in the final paper along with each individual's rough draft.
- Each member should sign the sign-off sheet. (See inside your group folder for the forms.)

Attachment 6

COMPANY NAME AND LETTER HEAD

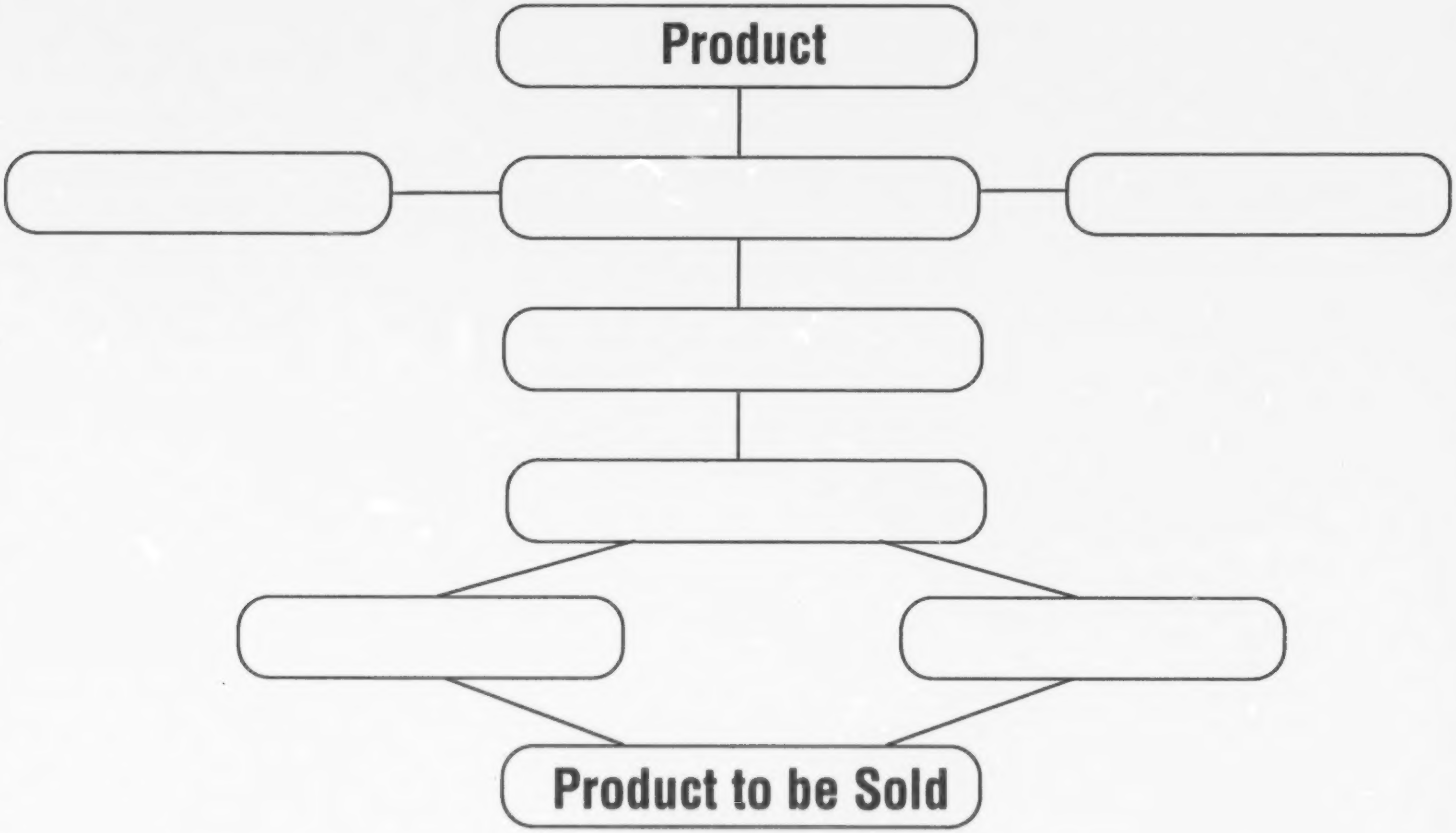
Begin to brainstorm a company name and letter head to be placed at the top of all future assignments. You may create a template using either CAD or Macintosh PageMaker.

- Each member should sign the sign-off sheet.
- You have two days to complete these two assignments.

Attachment 7

Sample Flow Chart

Outline the Steps to Complete the Project


Product
Product to be Sold

Attachment 8

SAMPLE COST SHEET

MATERIAL	PRICE	NO. OF PARTS/UNIT	PART COST PER UNIT
__________	_____	_____	_____
__________	_____	_____	_____
__________	_____	_____	_____
__________	_____	_____	_____
__________	_____	_____	_____
__________	_____	_____	_____
__________	_____	_____	_____
__________	_____	_____	_____
__________	_____	_____	_____
__________	_____	_____	_____

TOTAL UNIT COST _____

ATTACHMENT 9

MARKET ANALYSIS

After your group has decided on a product idea and written their product description, do the following assignment.

Write one page:

1. Describe your consumer: age, education, life style and gender.
2. Why will your consumer want this product?
3. Which advertising media would best target the consumer described above? (What kind of newspapers or magazines would your consumer be likely to read? What kind of television programs would your consumer be likely to watch?)

Create a questionnaire to test the market for your product. Give the questionnaire to the consumer type that you have targeted. (You might use your homeroom as an example. Try to get at least 25 responding to the questionnaire.)

Make a chart which shows the results of your findings.

This assignment has an extended deadline determined by when the questionnaire is completed.

Attachment 10

ADVERTISING CAMPAIGN

I. Develop the "Unique Selling Proposition"

The advertiser determines the best possible selling appeal to reach the consumer. (memorable slogan)

- A. a claim that the opposition cannot or does not offer
- B. a claim to help sell the product
- C. a claim that the product is "necessary" for some reason
- D. a claim that the product is superior to the competition

II. Create the Unique Selling Proposition based on Basic Appeals

- A. Mastery - to be better than others, appeals to vanity and a desire for recognition or prestige
- B. Hunger and Thirst
- C. Sex Appeal
- D. Parental Instinct
- E. Security
- F. Health
- G. Comfort
- H. Sociability, Joy, Pleasure
- I. Beauty
- J. Economy
- K. Convenience
- L. Shame
- M. Fear and Pity
- N. Humor
- O. Involvement

III. Advertising Copy

- A. Short Copy
  1. Personal, one-to-one style
  2. Logical order, leading off with a statement the prospect can nod in agreement with and conclude with an exhortation to action
  3. Clear, vigorous grammatical writing
  4. Lean, conscientiously edited prose

- B. Long Copy
  1. A short lead paragraph
  2. Lead sentence in boldface
  3. Subheads for key points
  4. Small illustrative visuals
  5. Indented paragraphs

Attachment 11

LIBRARY ASSIGNMENT

I. Working in your group, find ads which demonstrate each of the basic appeals in the handout. Be sure to write a description of each ad and how it is an example of the specific basic appeal. Some ads may use several appeals.

Be sure to name the product and the publication in which is appears.

There are 15 appeals to find. (See handout)

II. Look for tha following ads and write what you think is their Unique Selling Proposition:

Some of these ads are featured on television which you may also use.

- Dial Soap
- Raid
- Kraft Candies
- Kleenex
- Clairol
- Pepsi
- Sunkist
- Hallmark
- Coca Cola

You may substitute ads found in specialty magazines (horses, cars, sports) as long as you end up with 10 ads.

This Assignment is due ______________________________

Attachment 12

BASIC RULES OF ADVERTISING LAYOUT

1. Consistent internal margins among all of the elements. (Margins between copy, visuals, logos, need to be the same distance apart throughout the ad.)

2. Excess white space goes to the outside.

3. Group primary headlines with copy.

4. Play artworks and graphics large for attention getting value.

5. Target audience determines the amount of copy.

6. Type should suggest the kind of product. (For example, a fun, frivolous product would have an artistic font. A serious product would have a business-like font.) Generally, use clean simple fonts and sizes and styles.

7. The layout should show the placement of the headlines, copy, visuals or artwork, company logo and company name and address.

Attachment 13

GROUP EVALUATION QUESTIONNAIRE

Group No. ____

Leadership		Letter
1. Did one person dominate?	Y N	____
2. Did one person assume the role of a traffic cop?	Y N	____
3. No one assumed leadership.	Y N	____
4. Did one person hinder the group activity?	Y N	____
5. Did one person sit back and take credit for the rest of the group?	Y N	____

On Task

Rate your group for being on task. 1 2 3 4 5 6 7 8 9 10
No Yes

Assign a letter to each group member with yourself being A. Use the letter, replacing the name of the person, when you refer to the activities of one person.

MODULE 2: MATHEMATICS

INTRODUCTORY COMMENTS FOR TEACHERS

By

Peter Kloosterman, Indiana University, Bloomington
Thomas Benjey, Indiana University, Bloomington
Charles Emenaker, Indiana University, Bloomington
Joan Houston, Columbus East High School, Columbus
Richard Hurt, Bloomington North High School, Bloomington
Ross McKenna, Ben Davis High School, Indianapolis
Ronald Preston, Indiana University, Bloomington
Paola Sztajn, Indiana University, Bloomington

Abstract

This introductory material discusses the relationship between the prototype math units to the NCTM Standards. Pedagogical issues such as the use of calculators and grouping of students for cooperative learning are also discussed.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

INTRODUCTORY COMMENTS FOR TEACHERS

> *The importance of informal experiences for developing primitive conceptual understanding, a prerequisite to students' formal study and abstraction of mathematical ideas, should be recognized. In most situations, new mathematical ideas should continue to be introduced at the concrete level.* (NCTM *Curriculum and Evaluation Standards*, 1989, p. 131).

Background

The purpose of this introduction to the mathematics units is to guide Tech Prep mathematics teachers in the use of the following units in the classroom. Before discussing the units themselves, a bit more background is in order.

In 1989 the National Council of Teachers of Mathematics (NCTM) published the *Curriculum and Evaluation Standards for School Mathematics.* In this document, NCTM reported the results of a multi-year project to develop standards for mathematics curricula. Although there are separate standards for grades K-4, 5-8, and 9-12, four standards run throughout all grade levels. These standards are (1) mathematics as problem solving, (2) mathematics as communication, (3) mathematics as reasoning, and (4) mathematical connections. A second document, the *Professional Standards for Teaching Mathematics,* was released by NCTM in 1991 with the aim of describing *how* teachers can achieve the goals set in the 1989 *Standards* document. A major theme of the 1991 document was the notion that the teacher is a "facilitator of learning" rather than a "dispenser of knowledge." In other words, teachers need to set up classroom environments where students can figure out mathematical ideas for themselves. Although some lecture and explanation will still be necessary, the more that can be done to help students make sense of mathematical ideas on their own, the more likely they will actually retain the concepts they have learned. In addition, when students can do a mathematical problem several ways, they don't lose the ability to solve that problem if they forget one of the solution processes. The Indiana Department of Education affirmed the importance of the NCTM *Standards* when it revised its *Mathematics Proficiency Guide* to reflect the NCTM goals.

The Indiana Technology Preparation Curriculum is based on many of the same principles that NCTM and the Indiana Department of Education recommend. It can make mathematical ideas concrete through the use of applications-based curriculum. It involves problem solving, and certainly encourages students to work together and thus communicate mathematically. In brief, the Tech Prep curriculum helps students and teachers "shift towards connecting mathematics, its ideas, and its applications - away from treating mathematics as a body of isolated concepts and procedures" (NCTM, 1989, p. 3). In developing the Tech Prep mathematics units that follow, every effort has been made to see that they are consistent with the philosophy of Tech Prep and with the recommendations of NCTM and the Indiana Department of Education.

Using the Sample Mathematics Units in the Classroom

Two mathematics units are included in this module. The first is a unit on ratio and proportion, the second is a unit on solving systems of linear equations. The units were written so that they could be implemented by a mathematics teacher without help from other staff.

Undoubtedly, the units would be stronger if teachers of science, language arts, and technology were part of a team that was teaching them.

Are the units of value to preservice teachers?

On the assumption that most Tech Prep classes will be taught by experienced teachers, we have oriented the remarks in this introduction to experienced mathematics teachers who are teaching Tech Prep classes for the first time. However, this introduction, and the units themselves, should be valuable to preservice teachers who need to know more about Tech Prep. This introduction outlines some of the basic principles behind Tech Prep and the units show how those principles can be put into practice.

Where do the units fit into the Tech Prep curriculum?

The two units are intended to be *examples* of pedagogically sound Tech Prep mathematics curricula. They can be used alone or as supplements to textbook units on these topics. The ratio unit is fairly elementary and might fit best in the first semester of a Tech Prep mathematics course. The systems of equations unit assumes knowledge of basic algebra and thus may be more appropriate for a second or third semester course.

Our overall goal, when developing the units, has been to provide models of curriculum and teaching that were consistent with both the NCTM *Curriculum and Evaluation Standards* and the Tech Prep philosophy. *We hope that using these models will make it easier for teachers to adapt other mathematical topics so that they are taught in a similar fashion.*

Should students be given copies of each lesson?

The lessons in each unit are intended to be duplicated and distributed to students. There is space on the lessons for students to write answers to all questions that are posed. If you wish to use copies of the lessons more than once, you could have students write answers, make diagrams, etc., on separate paper or in a class notebook.

Can I adapt the units to fit the needs of my students?

The units are intended as suggestions and can certainly be modified as needed. The first unit (ratio) is the most detailed. We wanted to provide a very thorough example of how ratio concepts could be presented in a form consistent with the NCTM *Teaching Standards*. It is important that students be engaged in hands-on activities and that there be numerous opportunities for group work and discussion. Questioning of students to determine what they understand is also an essential element of the units. It is perfectly acceptable, within these guidelines, to modify the units to meet the needs of your students. In fact, we encourage you to modify the lessons. For example, if most of your students already have some grasp of ratio ideas, many of the examples can be shortened or omitted. If your students have not had algebra or have had little experience with ratios, you may have to add more activities. In certain situations, you may wish to use some of the lessons in a unit but not all of them. *We expect that in many cases, you will want to use problems from the ratio chapter of a textbook for homework or additional in-class practice.*

In general, the lessons in the unit on systems of equations are less detailed than the lessons in the unit on ratio. We assumed that after looking at the ratio lesson, you would want less guidance and thus have left details in the later unit to you.

How do students react to these materials?

While pilot testing of the materials is still in progress, most students enjoy the chance to be actively involved in doing mathematics. We must caution, however, that these units are considerably different than textbook mathematics. Many students are used to simply opening the book and doing problems. It may take them a while to adjust to the fact that they are to collect data, work in groups, talk with their partners, etc. You will need to help students understand their role as *active* participants in their own learning.

How should students be grouped to do the activities in the lessons?

In the units we have labeled each activity as individual, small group, or entire class. Most of the activities are small group activities and we recommend keeping the same groups of students together throughout each unit. Depending on your situation, you may need to change the extent to which you use small groups to meet the needs of your students. If you limit the amount of work that is done in groups, make sure that you provide ample opportunity for verbal interaction at some point during each lesson. Although large group discussion of findings is not mentioned after every activity, such discussion is a good idea if some students seem to be having trouble.

Additional detail on using small-group instruction can be found in many of the more general Tech Prep books and resources. A good source on using small-group instruction in mathematics is Neil Davidson's chapter in the 1990 NCTM yearbook titled *Teaching & Learning Mathematics in the 1990s.*

Should students be allowed to use calculators?

These units were written under the assumption that students would have unlimited access to calculators. Some of the problems can be done mentally, and you should encourage students to do them this way if they can. Many of the problems, however, involve "realistic" quantities. For these problems, calculators are clearly an asset.

Why are most examples in these units in metric?

Students should be able to use both the metric and English systems of measurement. Most of the examples in the units are metric because there is no need to worry about fractional quantities. As a challenge, you could ask your students to do some of the activities in English units instead.

It is important to point out that most of the graphing activities in the units call for graph paper ruled four squares to the inch. This was done because this size paper makes it easy for students to construct graphs which fit easily on a piece of graph paper without having to deal with fractional quantities. If your students are used to using metric paper, the activities can easily be adapted to fit metric grids.

Do I need to work with teachers from other subject areas to teach these units?

Ideally, you will be part of a team of teachers providing a Tech Prep curriculum that integrates technology, science, and language arts into most, if not all, lessons. The unit on ratio fits very nicely with ratio ideas commonly taught in science, making teaming with a science teacher quite easy. However, the units on ratio and on systems of equations are designed so that you can do them by yourself if you have to. We suggest that you require students to answer questions in the lessons in complete sentences. Writing skills are just as important in mathematics as they are in other subject areas! If you are part of a multidisciplinary team of teachers, you should be able to add home and workplace examples from other disciplines into the units.

How do I take different learning styles into account?

In general, different students learn best in different ways. In the mathematics units we have tried to provide written explanations, hands-on experiments, and practice exercises. Rather than let students do a mathematics problem only in the way they "like best," you need to encourage your students to try to solve the problems in several different ways. In fact, you will see places where we mention several procedures for solving the same problem. The NCTM connections standard is based on the idea that students who see several ways of doing a "school" problem are the ones who will be best able to apply their mathematical knowledge to problems they encounter in real life. In short, use a variety of techniques to convey a concept but also help your students see that concept from multiple perspectives.

How do I assess student learning of the concepts in these units?

State legislation requires that the Tech Prep curriculum be competency based. A key element of competency based instruction is that students should continue to study a concept until they master it. We agree that teaching for mastery is important, and it may require adapting the units to fit the abilities of specific students. We caution, however, that mastery is much more than "scoring 80% on a test." Many of the questions in these units are designed to determine if students can apply a concept in a different way than it was presented. Success in answering such questions is a strong indication that students understand the concept.

Performance assessment can be done through a combination of informal observation and questioning, evaluation of group work, and written testing. It can also include written papers and journal entries, assessment portfolios, individual and group presentations, and simulations which require students to use their skills in a job-like setting. Students often think they know more than they really do. Make sure your assessment system challenges them to prove they understand the mathematical concepts you are trying to teach.

Although a further discussion of assessment is beyond the scope of these units, there are several sources that provide good examples of performance assessment techniques. One is *Mathematics Classroom Assessment* which was developed by the Indiana Department of Education in 1992 as a supplement to the Indiana *Mathematics Proficiency Guide*. This source was sent to most schools in Indiana and is available from the Indiana Department of Education. A second source is *Mathematics Assessment: Myths, Models, Good Questions, and Practical Suggestions* by Jean Kerr Stenmark. This book was published in 1991 and is available from NCTM (it can be ordered by calling NCTM at 800-235-7566). A final source is the NCTM *Addenda Series*. This series of 22 brief volumes gives examples of how to teach in the style suggested by the NCTM *Standards*. Each topic area volume includes assessment ideas. In addition, several assessment volumes are planned. Although this series is still under development, most titles will be available by late 1992 or early 1993. Contact NCTM for more information.

Can I use computers with these units?

Given the variation from school to school in the availability of computers and software, we only included computer based explorations in one lesson (in the unit on systems of equations). If you have computers available, you could certainly use them. The first ratio lesson could be done with *CAD* (computer aided drafting) software or *Geometric Supposer* software. Many of the tables in the ratio unit could be done using a spreadsheet. In fact, a spreadsheet where one row is the product of another row and a constant is an excellent example of a ratio. *Derive* would be useful in the systems of equations unit. Graphing software or graphing calculators could be used as a supplement to the graphing activities in the units.

Where can I get additional applications based materials?

Unfortunately, there are not a lot of sources of realistic home and workplace applications of mathematics. Indeed, many "on the job" uses of mathematics are unique to a specific job and of little interest to someone who does not perform that job. Current high school textbooks tend to have more applications than were available even a few years ago. Some textbooks have supplements which include applications. NCTM has several applications-based titles and educational resource companies such as Dale Seymour Publications offer some books which outline applications. A comprehensive source of both hands-on experiments and workplace based word problems is the *Applied Mathematics* series published by the Center for Occupational Development. Titles in this series include most topics that Tech Prep mathematics courses normally cover. Although the format is not as inquiry oriented as the lessons presented in the units on ratio and systems of equations, there are still a number of usable activities. Finally, teachers from the Tech Prep demonstration sites in Indiana have developed applications-based curricula. When you visit a demonstration site, you should be able to get additional ideas for applications-based instruction.

Summary

Since the units in this module are considerably different than traditional textbook treatments of these topics, it may take some time for both teachers and students to feel comfortable with them. However, we hope that as you use them, you will find they provide insight into new and more effective ways to teach mathematics. Tech Prep programs are designed to be different from one community to the next. The units may need to be revised accordingly, but at the very least, they can serve as examples of applications-based instruction. As you experience Tech Prep teaching, we are confident that you will feel as we do: Teaching Tech Prep mathematics is not always easy, but it is good for students, rewarding for teachers, and enjoyable for all!

References

National Council for Teachers of Mathematics (1989). Curriculum and evaluation standards for school mathematics. 1906 Association Drive, Reston, VA 22091: Author.

MODULE 2: MATHEMATICS

UNIT 1

RATIOS

By

Peter Kloosterman, Indiana University, Bloomington
Thomas Benjey, Indiana University, Bloomington
Charles Emenaker, Indiana University, Bloomington
Joan Houston, Columbus East High School, Columbus
Richard Hurt, Bloomington North High School, Bloomington
Ross McKenna, Ben Davis High School, Indianapolis
Ronald Preston, Indiana University, Bloomington
Paola Sztajn, Indiana University, Bloomington

Abstract

Beginning with the ratio of the diameter to the circumference of a circle, continuing with gear ratios in a bicycle, and ending with Ohm's Law, this unit develops the concepts of ratio and proportional relationships.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

UNIT 1: RATIOS

Lesson 1

Radius, Diameter, and Circumference of a Circle

Objective: To find relationships between the radius, diameter, and circumference of a circle.

Materials:

- centimeter ruler and meter stick
- measuring tape in cm or piece of string about 5 m long
- 5 or more circular objects ranging in size from a coffee can to a bicycle wheel
- graph paper ruled 4 squares to the inch

Introduction

In this lesson you will investigate lengths of different parts of circles. Three common parts of a circle are the radius, diameter, and the circumference. Try to describe these parts in your own words to other members of your group. Can you think of when you might want to know the radius, diameter or circumference of a circle? (If you cannot remember the parts of a circle, they are explained at the end of this lesson.)

Activity One (small groups)

Find at least five different circles or circular objects. For the first object, measure the diameter using a centimeter ruler or meter stick. Record the diameter (in cm) in the table on the next page. Measure and record the radius as well.

To find the circumference of each object, measure around the outside with your measuring tape. If you do not have a cm measuring tape, you can measure with a piece of string and then find the length of string used with your meter stick. Record the circumference, rounded to the nearest cm. Repeat all measurements for the other objects.

Using your calculator, divide the diameter of each circle by its radius and enter the value in the table. Round your answer to the nearest tenth (one decimal place) and describe in writing what you found below. Does your result seem reasonable?

Now divide the circumference by the radius and enter the result in the table, again rounding to the nearest tenth. Finally, complete the table by dividing the circumference by the diameter and entering the value.

Object	A	B	C	D	E
Diameter					
Radius					
Circumference					
Diameter divided by Radius					
Circumference divided by Radius					
Circumference divided by Diameter					

How do the numbers in the row where the circumference is divided by the radius compare with the numbers in the row where the circumference is divided by the diameter? Discuss your answer to this question with the members of your group.

Now look at the numbers you have in the circumference divided by diameter row. Your numbers should all be about 3.1. What number do you think you would get if you divided the circumference of a circular wrestling mat by its diameter?

Regardless of the size of the circle you consider, you should get about 3.1 when you divide the circumference by the diameter. This number is called pi and commonly referred to with the symbol π. Recall from previous mathematics classes that $c = \pi d$ and $c = 2\pi r$ where c is the circumference, d is the diameter, and r is the radius of a circle. Calculate the circumferences of the circles you have been working with by using these two formulas. How do these computed values compare to the values in the table you just completed?

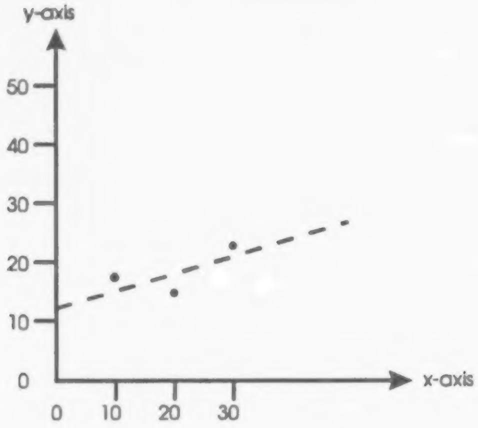
Activity Two (small groups)

In this activity, your group will create a graph of the diameter in relation to the circumference of a circle. Start by taking a piece of graph paper and creating an x-axis and y-axis as shown on the next page. Label the x-axis as diameter and the y-axis as circumference.

We usually make graphs as large as possible given the size of the paper we are working with because large graphs are easier to work with than small ones. We determine the largest scale that will fit on the paper by dividing the largest value to be represented along that axis by the number of squares on the axis. For example, we want to graph test scores that have a maximum of 100 per cent on graph paper that has 5 squares along the y-axis. By dividing 100 by 5 we determine that each square on the y-axis can represent 20 per cent. We then label our y-axis in increments of 20. That is, 20, 40, 60, 80 and 100. The origin is labeled zero. The little lines we draw where the squares on the graph paper intersect the axis are called tic marks. How would you label the axes for paper that has four squares in the y direction and 3 squares in the x direction when the largest y value is 40 and the largest x value is 30?

Sample Graph

(Yours should look somewhat different.)



The next step is to plot the points represented by the first and third rows from the table (diameter and circumference) on your graph. For example, if you measured an object that was 10 cm in diameter and had a circumference of 32 cm, you need to find 10 on the x-axis (labeled diameter) and 32 on the y-axis (labeled circumference). Go up from the 10 until you are across from the 32 and make a point. Use this method to find points on the graph that represent each of the objects in your table.

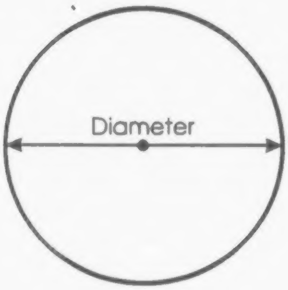
When all points have been plotted on your graph, take a ruler and draw a line that connects the points as closely as possible. You should have only one line with about half the points on each side. Discuss with your group what you think would happen if you measured other objects and plotted the diameter and circumference on the graph. Would the points be on or near the line you have drawn?

Now select and mark any two new points on your line. Draw a line straight down from the top mark and a second line going right from the bottom mark. Count squares to find the length of each of the lines you just drew. Label the lines with their lengths. Now divide the vertical (up and down) length by the horizontal (across) length. What number did you get? Try this three more times using other pairs of points on your line. We have just computed the slope of a line (the change in the y direction divided by the change in the x direction). What numbers did you get? Write a statement that explains what numbers you found and why those numbers make sense.

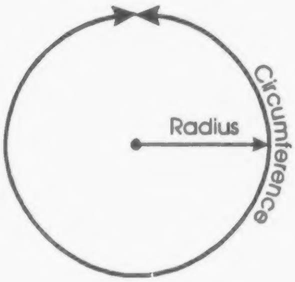
Optional Activity (small groups)

Repeat Activity Two to make two additional graphs. Use the radius and diameter measurements for your first graph and radius and circumference for your second. You should predict what number you will get when you compare vertical and horizontal distances between points before you actually do your division. Compare your predictions with the computed values.

Parts of a Circle



The diameter of a circle is the distance across the circle.



The radius of a circle is half the distance across or the distance from the center to the edge of the circle.

The circumference of a circle is the distance around or the perimeter of the circle.

Closing Discussion Questions (entire class)

When you divide the circumference by the radius of *any* circle, will you always get about 3.1?

If you measured the radius, diameter, and circumference in inches instead of cm, would it change the results of the experiment? (If time permits, you may want to try this out!)

Why do you get some numbers that are a little more or a little less than 3.1?

Why did we draw *one* straight line on the graph rather than "connect the dots"?

Is there a relationship between π and the slope of a line?

Lesson 2
How Far Do Wheels Travel?

Objective: To understand the relationships between gear size and speed for various gears on a bicycle.

Materials:

- different sized bicycles with 10 or more gears
- meter stick or metric tape measure
- chalk
- masking tape

Introduction

Have you ever noticed that when you are bicycling, the distance you travel is related to the number of revolutions the wheels make? Have you ever realized that the more you pedal, the more your wheels turn, and the farther you go? In this activity, we will look at the relationship between the number of times you pedal and how far you travel.

Activity One (small groups)

Choose one bicycle and make a small chalk mark on the side of the tire. Make a small mark on the floor using chalk or masking tape. Place the bicycle so that the chalk mark on the tire is exactly lined up with the mark on the floor.

Push the bicycle forward so that its wheel makes one complete revolution. That is, the mark you made on the tire will rotate exactly once. Mark this spot and measure the distance (to the nearest cm) between this spot and the spot where you started. Record the distance in the table below.

Revolutions	1	2	3	4	5
Distance (cm)					

Now let the wheel make two revolutions. Measure the distance traveled and enter it in the table . Let the wheel make 3, 4, and 5 revolutions and complete the table.

Discuss with the members of your group how far you think the wheel would travel if it made 6, 7, or 8 revolutions. Enter your predictions in the table on the next page. Check your predictions by measuring the distance traveled after 6, 7, and 8 revolutions.

Revolutions	6	7	8
Predicted Distance			
Actual Distance			

With the members of your group, make a prediction about how many times the wheel would turn to travel 20 meters. Write, in the space below, how you arrived at your prediction.

Now mark a distance of 20 meters. Line your tire mark up with the start of the 20 meter path and push the bicycle to the 20 meter mark, counting the number of revolutions of the wheel. How accurate was your prediction?

Work with your group to make a table which shows how many revolutions the wheel would make if you traveled 20, 40, 60, 80, or 100 meters. Base your table on predictions rather than measurements.

Activity Two (small groups)

Repeat activity one using a bicycle with a larger or smaller wheel. As you go through the beginning steps, try to predict how far the wheel will travel.

Optional Activity (small groups)

Make a graph of distance traveled (x-axis) in relation to the number of revolutions of the wheel (y-axis) for each bicycle.

Activity Three (small groups)

Using the measuring tape, measure the diameter of the wheels of the bicycles that you have used. Discuss with your group how the diameter of the wheel is connected to the distance traveled in each wheel revolution. (Recall the formulas discussed in the lesson on ratio, diameter, and circumference.)

Now choose a third bicycle and measure the diameter of its wheels using the measuring tape. Discuss how can you find out how far this bicycle will travel for each revolution of its wheel. Using only your measurement of the wheel diameter, construct a table for the third bicycle which shows the distance it will travel after 1, 2, 3, 4 ,5, 8, and 10 revolutions of the wheel. Roll the bicycle to check your predictions for 1, 5, and 10 revolutions. If your predictions were not accurate, explain in writing why they were incorrect.

Activity Four (small groups)

Instead of finding the relation between the number of wheel revolutions and the distance traveled by the bicycle, we will now look at the relation between the number of *pedal* revolutions and the distance traveled by the bicycle. Take a bicycle with 10 or more gears and discuss with your group how the gear system works. Which are the fastest gears? Which gear do you want to use when going up a steep hill?

Carefully shift your bicycle into its lowest gear (smallest sprocket on the front, largest on the back). Turn a pedal one full revolution and look at how far the rear wheel turns. (Mark the tire with chalk or just watch the valve stem to see how many times the wheel turns.) Discuss with your group how far (in meters) you think the bicycle will travel after 1, 5, and 10 revolutions of a pedal. Write your guesses below so that you can come back to them at the end of this activity and see how accurate they were.

Your task now is to complete the following table.

Revolutions of the Pedal	1	2	3	4	5	8	10
Predicted Distance (cm)							
Measured Distance (cm)							

Were your predictions accurate? If not, why not?

Now let's change gears. Leave the front sprocket as it is but shift the gears so that the chain is on the second largest rear sprocket. Measure the distance traveled after one revolution of the pedal. Record that measurement in the table below and fill in your predictions for the rest of the table. Check your prediction for 5 revolutions of the pedal. If your prediction is accurate, move on to the next part of the lesson. If your prediction is not close to the measured value, revise all your predictions and then check one of them.

Revolutions of the Pedal	1	2	3	4	5	8	10
Predicted Distance (cm)							
Measured Distance (cm)							

The next table that you will complete shows distance traveled for each of the 5 lowest gears on your bicycle. Gears are numbered on a bicycle with first being the slowest (smallest sprocket on the front, largest on the back), second being the next (smallest on the front, second largest on the back), and so forth. If the bicycle you are looking at has more than five gears on the rear sprocket, just look at the largest (i.e., slowest) five. Measure the distance traveled for one revolution of the pedal and then predict distance traveled for five and ten revolutions. (You already have this information for the first and second gears!)

Gear	First	Second	Third	Fourth	Fifth
One Revolution (measured)					
Five Revolutions (predicted)					
Ten Revolutions (predicted)					

How many revolutions of the pedal would be necessary for the bicycle to travel 100 meters or 1000 meters in first gear? Discuss this question with your group and record your answer in your notebook. How many revolutions of the pedal would be necessary for the bicycle to travel 100 meters or 1000 meters in fifth gear? Again, discuss and record your answer.

Activity Five (small groups)

How many teeth are there on each sprocket of your bicycle? To check, mark one tooth with chalk and then count teeth until you get back to the marked tooth. Repeat for all front and rear sprockets. Record the information below.

Rear Sprockets:

Front Sprockets:

Discuss with your group how the number of teeth in each sprocket is related to the speed of the bicycle if the speed of pedaling remains constant. What do you think will happen to the speed of the bicycle when you keep the chain on the largest front sprocket but change the rear sprocket from the lowest gear to another one with half as many teeth? When the chain is on the smallest front sprocket and smallest rear sprocket, will the bicycle go faster or slower than when the chain is on the largest front sprocket and largest rear sprocket? How can you test your prediction? Record your answers to these questions in the space below.

We will now look at speed of a bicycle based on the gear being used. Complete the table below for the lowest 12 gear combinations on your bicycle. (If your bicycle has only 10 speeds, you do not need to record anything in the columns for gears 11 and 12). **Remember that the first gear (lowest) has the smallest sprocket on the front and the largest on the back;**

the second gear still has the smallest sprocket on the front but the second largest on the back. When you want to change from the fifth to the sixth gear (assuming you have five sprockets on the back), you have to go from the smallest sprocket in the front and smallest in the back, to the largest sprocket in the front and the largest in the back. Finally, when you get to the tenth gear you will have the largest sprocket on the front and the smallest on the back.

To complete the third row of the table, divide the number of teeth in the front sprocket by the number of teeth in the rear sprocket. Round your answer to two decimal places. Fill in the fourth row of the table by looking at row three. The slowest gear will be the one with the smallest number in row 3. The second slowest will be the one with the second smallest number and so forth. When you are finished, row four should have the numbers 1 through 12 (or 1 through 10 if you have only ten speeds).

Gear	1	2	3	4	5	6	7	8	9	10	11	12
Number of teeth in front sprocket												
Number of teeth in rear sprocket												
Row 1 divided by row 2												
Gear (based on speed)												

Answer the following questions based on the completed table.

1. Why are the gear numbers in row 4 different than the gear numbers at the top of the table? How could you design a bicycle so that row four was the same as the top of the table?

2. About how many times faster is the fastest gear compared to the slowest gear?

When you have finished this assignment, save your work. You will need it again in lesson 6!

Closing Discussion Questions (entire class)

- Explain the following statement: If your bicycle is in a gear where the chain is connecting a sprocket with 44 teeth in the front to one with 22 teeth in the back, it will travel at the same speed as if you had 50 teeth in the front and 25 in the back.

- Find additional combinations of gears that would be the same speed as having 44 teeth on the front sprocket and 22 teeth on the rear sprocket.

- Is it possible to have the same speed as above when the chain is on a front sprocket with 51 teeth.

- Mountain bikes and bikes for use in hilly areas often have three front sprockets, the smallest having only 28 teeth. Why would you want a gear this small on the front?

- A common set of rear sprockets (called the freewheel) on a racing bicycle has gears with 13, 14, 15, 16, 17, and 18 teeth. The front sprockets (called the chainwheels) often have 44 and 52 teeth. Would this be a good combination to use in a race over hilly or flat roads? Why do you think racers use this combination of gears?

Further Exploration

You may wish to visit a bicycle shop and get a gear chart which shows how the numbers of teeth in the sprockets relate to the distance traveled by the bicycle. A major factor in deciding which gears to put on a bicycle is how to avoid having too much gear overlap. In other words, if the speed you are going is about the same with several combinations of front and rear sprockets, you have fewer choices of speeds that you can travel when pedalling at a constant pace. Look at different types of bicycles and determine how much overlap there is in the gears they have.

Lesson 3
Ratios

Objective: To understand the concept of ratio using tables, graphs, and a formal definition.

Materials:
metric and English rulers
graph paper ruled 4 squares to the inch

Introduction

In the previous activities, we constructed a number of tables. Once we knew the first numbers in the table, we were often able to predict what the next numbers would be. Whenever we can predict numbers in one row of a table by multiplying numbers in another row of a table by a given number, we call the relationship between the numbers a **ratio**. There are ratios in which both items have the same units (they are often called proper ratios). For example, when we compared the diameter of a circle to its circumference, both measured in centimeters, we were using a same units ratio. Miles per gallon is a good example of different units ratios. If we did not specifically state that we were comparing miles to gallons, there would be no way to know what was being compared!

Activity One (entire class)

Look back at the tables you made in the previous lessons in this unit. Which numbers that you predicted were same unit ratios and which were not? Enter two examples of same units and two examples of different units ratios below.

When both quantities in a ratio have the same units, it is not necessary to state the unit. For instance, let's compare the quantity of chocolate chips used when Mary and Quinn bake cookies. If Mary used 6 ounces and Quinn used 9 ounces, the ratio of Mary's usage to Quinn's would be 2 to 3. How do we get this? One way would be to build a table where the second row was always one and a half time as much as the first row. This is the method we used in the first two lessons. Another way is to express the items being compared as a fraction complete with units:

$$\frac{6 \text{ ounces}}{9 \text{ ounces}}$$

Notice that both numerator and denominator have the same units and thus we can "cancel out" the units. Notice also that both numerator and denominator have values that are divisible by three. When expressing ratios, we generally treat them like fractions and reduce them to the smallest numbers possible.

Ratios can be written in a variety of forms. The ratio of 2 to 3 can be written using a colon (2:3) or a fraction (2/3). Look back at the table of the number of teeth on the front sprocket of a bicycle compared to the number of teeth on the rear sprocket. How could you write those ratios using a colon and using a fraction? Discuss this question with the individuals around you and then write several examples of bicycle gear ratios below.

To determine the speed of the bicycle in each combination of gears, we divided the number of teeth in the rear sprocket into the number of teeth in the front sprocket. How could bicycle gear ratios from the table in activity five of the last lesson be written in colon form? Why did we not write these fractions in colon or fractional form?

Activity Two (small groups)

In manufacturing, it is important to keep track of the number of defective parts or products being produced. Rather than simply counting the number of defective parts, company officials usually consider the number of defects *per* hundred, thousand, or million parts. Suppose that the Lightning Electric Company was making complex light switches and had a defect rate of 25 parts per hundred. Why would the figure 25 parts per hundred be considered a ratio?

In the space below, make a table with showing the number of parts produced in the top row and the number of defective parts in the bottom row. The top row should have the entries 100, 200, 300, 400, and 500.

Look at your table. What number must you multiply the bottom row by to get the top row? (If you are not sure, take a guess and use your calculator to check that guess.)

What number must you multiply the top row by to get the bottom row?

We are now going to graph this ratio on graph paper. Each line on the graph paper should represent 25 units. The number of parts should be represented on the x-axis and the number of defects should be represented by the y-axis. Plot the points listed in your table and then connect them with a line. (If necessary, review the graphing example in lesson one). Now find a point on your line that is between two points. Draw a horizontal line from your new point to the y-axis and measure it in millimeters. Record the distance below. Continue by drawing a vertical line from your new point to the x-axis. Measure and record.

Horizontal distance:

Vertical distance:

What number must you multiply the horizontal distance by to get the vertical distance?

Explain, in writing, how the number you just found relates to the top and bottom rows of the table.

Do you think that choosing a different point on the line and repeating the measurements would result in a different ratio of the horizontal distance to the vertical distance? Why or why not?

Activity Three (small groups)

Draw squares with sides of 3 inches, 4 inches, 6 inches and 8 inches on graph paper. Draw and measure (in cm) the length of one diagonal (a diagonal connects two opposite corners) for each square. In the space below, make a table showing the length of the side and the length of the diagonal for each square.

What is the ratio of the length of the diagonal to the length of one of the sides for each square?

Do you think the ratio will be the same for any square?

Closing Discussion Questions (entire class)

- If your speedometer needle is pointing to 55, what ratio is indicated? What kind of ratio is it (same units or different units)? How would you state this ratio formally? How would you write it?
- Most car speedometers have both English (miles per hour) and metric (kilometers per how) units. How could you make a table to show the ratio of miles per hour to kilometers per hour?
- In the first lesson in this unit, we referred to the number *π*. Does *π* represent a ratio? Why or why not?
- Can all ratios that are represented by tables be represented by graphs? Is the graph of a ratio always a straight line?
- How could you make a graph from the colon form of a ratio without making a table first?
- If you have had first year algebra, you may remember discussing the slope of a line. How is the slope of a line related to the ratio between the vertical and horizontal distance between two points on the line?

Lesson 4
Scale Drawing

Objective: To understand how ratios can be used to create scale drawings.

Materials needed:

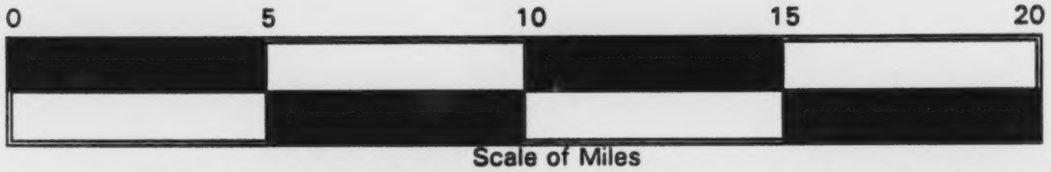
Indiana state maps
12 inch rulers
graph paper ruled 4 squares to the inch

Introduction

Have you ever wanted to take a trip? Find lost treasure? Rearrange your room? All of these activities can involve the use of scale drawings. This lesson will give you an opportunity to read and create scale drawings. Let's start with a situation you might find interesting. Our hero, Al Bumbly, has accumulated several thousand dollars which he wants to hide from his spendthrift wife. Since Al doesn't trust banks or understand the concept of interest, he decides to bury the money in a shoebox in the back yard. Knowing that his memory sometimes fails him and that he would want the money to go to his heirs should something happen to him, he realizes that the exact location of the money should be recorded somewhere

Al used a tape measure when locating the hole in which the treasure is buried, so he knows the exact position of the hole. Knowing that pictures often portray information more clearly than words, especially to people having the Bumbly reading ability, Al surmised that making a map of the yard was the best approach. The Bumbly back yard is 100 feet wide. This fact posed quite a problem for Al when he went to the local office supplies store to get paper on which to draw the map. He would have to tape many strips of paper together to make a piece as large as his yard. Al then realized that his yard contained trees, shrubs, lumps, holes and broken bicycles making it impossible to trace the exact location of the treasure on paper even if he could make a large enough piece. Al was stumped. He knew that people routinely made maps and drawings of large things like his yard, but how did they do it? As luck would have it, Al tripped on a carpet in the store while pondering this momentous problem and knocked over a rack containing maps. Al looked at one of the maps and noticed that the entire state of Illinois was represented on a single piece of paper. He studied the map closely and observed that the entire city of Chicago was only a few inches long on the map. How could that be? From experience he knew that it was several miles from one end of town to the other as he had walked it before he found out about buses and the El.

Al found a large table in the back of the store where he was able to spread the map out across the table. In the lower right corner of the map, he found a block labeled legend. "Wow!" thought Al, "There must be some great story tied to this map." He looked all over both sides of the map and found no stories at all. Disappointed, he looked closely at the legend block and, to his surprise, found a funny looking dashed line a couple of inches long. The words "scale of miles" were printed just below the dashed line. A zero was printed just above the left end of the line and the numbers 5 through 20 were printed just above the line. What could all this mean?



Scale of Miles

Al pondered this funny looking line for a while and thought, "Five miles, hmmm." It's five miles from home to the bowling alley. He found his house on the map and also where the bowling alley is located. He drew a line between these two points when the clerk wasn't looking because he had no intention of buying the map. He looked at the line he had just drawn and the funny dashed line. They were about the same length. Could this be? Could that funny line in the legend mean that a half inch on the map is the same as five miles on the ground? Al asked the clerk about this.

The clerk explained that since it is impractical to make full size maps, it is the usual practice to make scale maps. Scale maps represent some large area on a small piece of paper by using a small distance on the paper to represent a long distance in nature. This technique is called scaling. The clerk told Al about other examples of scaling such as model cars. Al then recalled having built a plastic model of a Corvette that had 1/24th scale printed on the box, but didn't know what it meant. The clerk explained that the model was one twenty-fourth as large as the real car. That is, twenty-four inches of the real car are represented by one inch of the model.

The clerk showed Al that by placing a ruler on the map, he could measure the distance between points in inches. If Al knows the scale of the map, he can convert the scale measurement in inches to the actual distance. By measuring the scale in the legend on the map, he found that 2 inches on the map represent an actual distance of 20 miles. The clerk suggested to Al that he determine how many miles one inch represents to simplify future computations. How can Al determine how many miles are represented by one inch?

Activity One (entire class)

Before helping Al draw his map, let's do some preliminary work. We are considering a little car trip and need to know how far we will be driving. Take out a map of Indiana and find the towns of Scottsburg and Memphis. (They are near I-65 between Indianapolis and New Albany.) If we are to drive from Scottsburg to Memphis via I-65, how far will we travel? How do we determine distances on scale maps? First, let's measure the legend (called the "explanation" on some maps). Notice that the legend is for 20 miles. How many inches represent 5 miles? How many miles are represented by 1 inch on the map? Now determine how many inches it is from Scottsburg to Memphis on the map. How many miles does this represent?

We want to consider one portion of Indiana for our trip which will take us from Bedford to Uniontown to Henryville to Paoli and back to Bedford. Find the towns on the map and notice that the path we will be following is almost a rectangle. Suppose that we need to know the perimeter of this region? How do we compute the perimeter of a quadrilateral (four sided figure)? What information must we get from the map?

For starters, what is the distance from Bedford to Uniontown? How did you get that figure? After you have the distance from Bedford to Uniontown, it is possible to make an estimate of the maximum and minimum possible values for the perimeter. What are your estimates? How did you determine these amounts? Now gather the rest of the data needed from the map and compute the distance for the entire trip. What answer did you get? Is it more than the minimum and less than the maximum possible values? If not, why not?

Activity Two (small groups)

Now that we have a basic understanding of how scaling works on a map, it appears that it will be possible to draw a map of Al's yard on a small piece of paper. Al looked around the store and found an inexpensive tablet of $8^1/_2$" by 11" paper full of squares 1 inch in size. Since Al was unwilling to spend more money, larger paper was out of the question.

Our project is to draw a map of Al's yard and to locate the hidden treasure on it. The first decision we must make is to select a scale for our map. Usually map makers want to make a map as large as possible so it can be read easily. Al's yard is 100 feet by 80 feet and the squares on the paper are 1 inch on a side. What distance will you represent with one square on the paper? Work with your group to decide on a reasonable scale. Express this scale as a ratio in colon form such as 1 inch:10 feet.

Al's lot is 100 feet long on the east and west sides so orient your map so that the longer sides of Al's yard are parallel to the longer sides of your paper. Mark the orientation of your map by making an arrow pointing to the top edge of your paper and marking that arrow as north. Al's ranch house is 25' (north/south) by 60' (east/west) set back 20' from the North property line and centered across the width of the property. The 30" wide back door is on the south wall of the house thirty inches in from the east wall. Draw the outline of the house showing the position of the back door.

The Bumblys have a 20' by 20' garage located ten feet in from the east property boundary with its front wall even with the south property line. Draw the outline of the garage. There are two large trees of significance in the back yard. The old willow tree is located convenient to the septic tank 15 feet due south of the southwest corner of the house. The oak tree with the faded yellow ribbon is ten feet west of the center of the west wall of the garage. Put a W where the willow tree is located and an O where the oak tree is located.

Now that we have the Bumbly's yard laid out, we can help Al determine where he buried the treasure. From watching old movies Al learned that it is best to locate the hole with respect to more than one permanent landmark should one of them be destroyed or, worse yet, moved. He started at the back door using the center of the door as a reference point. Al went south 15 feet and turned right. He walked west until he bumped into the willow tree, then walked south 30 feet where he turned left and walked 30 feet east until he encountered the oak tree. From this point, he stepped 15 feet north and dug the hole. Mark this spot on the map with a large X that crosses on the exact spot.

Activity Three (small groups)

Take a map of your city and locate your home, school, and three other points of interest such as stores, a friend's home, or the public library. Using the scale on the map, determine how far it is from your home to each of these places. Determine the distance using the route you would normally take to get from your home to each of these places. Also, determine the distance if you could take a helicopter from your home and thus go straight over buildings and other obstacles that you must normally go around.

Further Exploration

Find a blueprint of a house or small building. Discuss the scale used and exactly how large a building constructed from your blueprint would be. Using tape, outline the actual size of one of the rooms on your classroom floor.

Closing Discussion Questions (entire class)

- How are map scales like ratios? Would it be possible to provide a table instead of the map scale? What would such a table look like?

- When you read the mileage table on a road map, the distance shown between cities is often a little different than the distance you get by measuring. Why is this the case?

- If we used metric rather than English units to make Al's map, would it be harder to find the treasure?

- All of the scales we have used in this lesson are ratios that have units. Is it possible to have a map drawn using a same units ratio? Explain.

Lesson 5
Putting It All Together

Objective: To find examples of ratio in newspapers, magazines, and in real life situations.

Materials:

USA Today and other newspapers
various news and consumer magazines

Introduction

Now that you have completed the first four lessons in this unit, we hope that you noticed that ratio is a concept that is used in a variety of mathematical situations. We have measured radius, perimeter, circumference and distance; constructed tables; and predicted values to show different applications of ratio. We have also used ratios to read maps. In this lesson we will look at ratios in a new setting: in newspapers and at various places at school and at home.

Activity One (individual or small groups)

It is very common to find ratios in the sports and business sections of the newspaper, or in magazines such as *Newsweek* or *Consumer Reports*. Look through a magazine or newspaper to find examples of ratios. The ratios may be in fraction form, colon form, or even graphical form. Try to find as broad a variety of situations that have ratios as possible. Do all graphs represent ratios?

Activity Two (small groups)

Discuss the examples of ratio that each member of the group found. How many are same units ratios and how many are different units ratios? What was the purpose of reporting each of these ratios in the newspaper or magazine? Was use of the ratio (in fraction, colon, or graphical form) a good way to get a point across? What predictions could be made from the ratios that you found?

Try to think of other situations where you use ratios and discuss the predictions that you can make when you know ratios. Write down, in the space below, two examples where you could use ratios.

Optional Research Activity (small groups)

Collect data to answer some or all of the following.

1. What is the ratio of teachers to students in your school? Is this ratio the same for all subject areas?
2. What is the ratio of "popped" to "unpopped" kernels in various brands of microwave popcorn? (Get several brands of microwave popcorn and try this out!)
3. What percentage of the day do students in your class spend reading? (Why can percentage be considered a ratio?)
4. Consider the statement "There are twice as many *Coke* drinkers as *Pepsi* drinkers in the class." Survey your class (or another class) and make similar statements about the soft drink preferences of the students.
5. Form your own question(s) and collect data. Express your findings using ratios.

For each of the questions you researched, explain in writing how you collected the data you needed to find the ratio stated. Also, explain whether you think the same result would be found if you did your survey again using a different school, new bags of popcorn, or a different class.

Closing Discussion Questions (entire class)

- If a cook needs to make twice as much food as he or she usually does, is he using ratio? Why is a recipe a ratio?

- The *Always in Style* clothing store is having a sale. Everything in the store is 25% off. How can this be written as a ratio?

- Why do you think newspapers such as *USA Today* use graphs rather than stating information using tables or other forms of ratios?

Further Exploration (group project)

Ratios are often used on the job. For example, a cook uses ratios to follow recipes, a sales person uses ratios to calculate percentages and discounts, a nurse uses ratios to calculate medication needed, a carpenter uses ratios to find the size of boards needed, etc. Interview someone who uses ratio on the job to see how frequently that individual uses ratio and other mathematical concepts. Find out what happens if a mistake is made.

Lesson 6
Proportions

Objective: To set up and solve proportions.

Introduction

When you were studying and discussing ratios, you were also using proportions. A **proportion** is statement indicating that one ratio is equal to another. The purpose of this lesson is to help you to understand proportions and how to use them to answer mathematical questions.

Activity One (entire class)

Go back to Lesson 2 and see how you completed the following table:

Revolutions	1	2	3	4	5
Distance (cm)					

To complete the table you measured the distance the wheel traveled after 1, 2, 3, 4, and 5 revolutions. At this point, however, you realize that the distance traveled after five revolutions was about five times the distance traveled after one revolution. This is an example of a proportion. If you had a 27" wheel on your bicycle (and thus about a 30" or 76 cm outside tire diameter), you could say that the wheel rolled 239 cm after one revolution. The ways you could write this ratio include:

$\frac{1}{239}$	(number of revolutions) (number of cm)
1:239	(number of revolutions: number of cm)
1 to 239	(number of revolutions to number of cm)

The wheel would roll about 5 x 239 or 1195 cm in 5 revolutions.
Mathematically, we can write this proportion most easily using fraction form. Specifically:

$$\frac{1}{239} = \frac{5}{1195}$$

Notice that the numbers in each fraction are just entries from the table! It is always possible to write a proportion using two sets of numbers from a ratio table. Be careful to write the numbers as if they were entries from the table. Otherwise, the fractions you write will not be equal. (If you are not sure that 1/239 is equivalent to 5/1195, calculate both on your calculator to see what you get.)

In the space below, write the proportions which relate the distance traveled in one revolution to the distance traveled in 2, 3, and 4 revolutions.

Activity Two (entire class)

In lesson 2 you discussed the following statement: "If your bicycle is in a gear where the chain is connecting a sprocket with 44 teeth in the front to one with 22 teeth in the back, it will travel at the same speed as if you had 50 teeth in the front and 25 in the back." Recall what you said about this statement.

Explain the statement above using the idea of proportion. Specifically, write this statement as a proportion in the space below. Think of other gear combinations that you could have that would give you the same proportion and write them down.

In lesson 4 (Scale Drawing), you used the scale of 1 inch:10 feet for drawing a map of Al's yard. Suppose there was an old tarp on your map of Al's yard. On the map, the tarp measured 2 inches by 5 inches. Write proportions showing the actual width and length of the tarp. (Hint: Think of a table where the top row has an entry of 1 inch and the bottom row has an entry of 10 feet. What would be the bottom row entry when the top was 2 inches or 5 inches?)

Now suppose you wanted to add a junked car which was 5 feet wide and 15 feet long to the map. Write proportions showing what width and what length the car would be on the map.

Rather than thinking of a table, we can go directly to the fraction form of a proportion, using a variable to represent the row in the table that is missing. For example, we could write the ratio for the width of the tarp as:

$$\frac{1}{10} = \frac{2}{X}$$

We could write the ratio for the width of the car as:

$$\frac{1}{10} = \frac{X}{5}$$

To find X in the first proportion we *think* "The denominator of the first fraction (10) is ten times the numerator so the denominator of the second fraction must also be 10 times as big (50)." To find X in the second proportion we *think* "What number, when multiplied by 10 gives 5? It must be .5" When numbers get too large to do in your head, use a calculator.

Use a calculator to find 221/17.

Now use your result to find X:

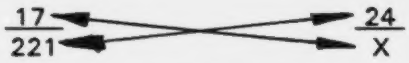
$$\frac{17}{221} = \frac{24}{X}$$

Suppose the proportion was written:

$$\frac{221}{17} = \frac{X}{24}$$

Solve for X in the above proportion. How does your result compare to the previous problem?

To find the missing term in a proportion (X) one technique that is commonly used is to "cross multiply and divide." To use the technique, you must *multiply* the denominator (bottom number) of one fraction by numerator (top number) of the other and set it equal to the second denominator multiplied by the first numerator. The arrows show which numbers to multiply.



In other words:

$$17X = 221(24)$$

Solving for X:

$$17X = 5304 \qquad \text{(multiply 221 x 24)}$$
$$X = 312 \qquad \text{(\textit{divide} both sides of the equation by 17)}$$

In brief, proportions involving a variable are always set up like the numbers in a table. They can be solved by (a) finding out what the numerator of the first fraction be multiplied by to get the denominator of that fraction and then using the same multiplier on the second fraction, or (b) cross *multiplying* the numerators and denominators and then *dividing* by the number which is multiplying X.

Activity Three (individual)

Solve the following proportions:

$$\frac{15}{240} = \frac{18}{X} \qquad \frac{23}{253} = \frac{11}{X} \qquad \frac{441}{14} = \frac{X}{27}$$

$$\frac{12}{360} = \frac{X}{480} \qquad \frac{212.5}{8.5} = \frac{500}{X} \qquad \frac{80}{120} = \frac{363}{X}$$

Activity Four (small groups)
Answer the following using complete sentences:

1. If you are travel 203 miles in 3.5 hours, how far will you travel in 8 hours (assuming you maintain the same speed)?

2. A pump can pump 48 gallons of water in 3 minutes. How many gallons can it pump in 45 minutes? How many gallons can it pump in 2 hours?

3. A map has a scale of 1/4 inch (which can be written as .25 inch) to 20 miles. How far apart are two towns that are 2 1/2 inches apart on the map?

4. Ed's Golf Outlet is giving 5 free golf balls with every dozen purchased. Amy bought twelve dozen golf balls. How many did she get free?

5. A stamping machine will can make 46 parts in a half hour. How many parts can it make in a full 8 hour shift?

6. A kilometer is approximately 1.6 miles. How many miles per hour is a car traveling if it is moving at 90 kph (kilometers per hour)?

Closing Discussion (entire class)
When setting up a proportion, John said that

$$\frac{10}{50} = \frac{20}{X}$$

was the same as

$$\frac{10}{50} = \frac{X}{20}$$

Why was John incorrect? How can you make sure that you always have "X" in the correct position when setting up a proportion?

Lesson 7
Inverse Proportions

Objective: To set up and solve inverse proportions.

Materials:
- meter stick
- different weights (from 5 to 500 g)
- fulcrum
- calculator

Introduction

All the proportions that you have studied are a special type of proportion called a **direct proportion**. In direct proportions, when one row of a table showing the proportion gets larger, the other row or rows get "proportionally" larger. You can always find a row by *multiplying* the numbers in another row by some specific number. In this lesson, you will learn about **inverse proportions**. In these proportions, one row gets smaller at the same time another gets larger. For example, think of how long it would take you to paint your room. How long would it take if you had one friend helping you? How long would it take if you had two friends helping you? The relation between the time it takes to paint your room and the number of people painting is an inverse proportion. The more people you have, the less time it takes (or at least the less time it should take!)

- Think back to earlier lessons in this unit and answer the following questions:

- What happens to the circumference of a circle when its diameter increases?

- What happens to the distance traveled by your bicycle when the number of wheel revolutions increases? What happens when the number of pedal revolutions decreases?

Think about your everyday experiences. In each of the cases below, what happens to the quantity at the right when the quantity at the left increases? And when it decreases?

unit cost	total cost
time traveled (constant speed)	distance traveled
distance in feet	distance in meters
size of a gas tank	cost to fill-up

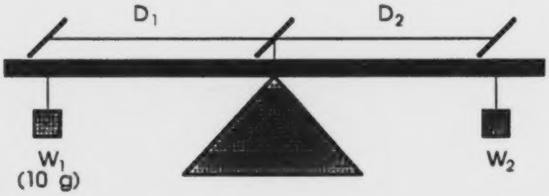
As you may have guessed, these are all direct proportions, both either increase together or decrease together. More specifically, they increase or decrease at the same rate.

Activity One (small groups)

In this activity we are going to do an experiment which involves inverse proportions. Your task is to complete the following table:

Weight (W_2) (unit: grams)	10	20	40	60	80	100
Distance (D_2) (unit: mm)						

To do so, set up your meter stick, fulcrum, and weights as shown below:



Your objective in this experiment is to balance the meter stick on top of the fulcrum, using two weights. Start by centering the meter stick on the fulcrum. Choose a 10 g weight, let's call it W_1, and hang it at a distance D_1 (about 40 cm) from the fulcrum. This weight will be kept fixed in this position (you might use some tape to be sure that W_1 will not move during the experiment).

Now get another 10 g weight (W_2) and move it along the stick until you manage to balance W_1. Complete your table by reading or measuring the distance (D_2) from the fulcrum to the weight and writing it down. Repeat for 20 g and 40 g. What happens with the distance as you increase the weight? How far from the fulcrum do you think an 80 g weight will need to be in order to balance W_1? And a 100 g weight? Do the experiment and check your predictions as you complete the table. Why is this not a direct proportion?

Activity Two (entire class)
There are other quantities that are also related in the same way as the weight and the distance in your experiment. Consider the following variables:

speed of a car	time spent traveling
number of workers	time needed to finish a task
length of a hammer handle	effort needed to pull a nail

How are they related? What happens to the quantities at the right when the ones at the left increase?

Now let's look back at our experiment. Copy the second row of the last table into the table below and then calculate the third row by multiplying the first and second rows together.

Weight (W_2) (unit: grams)	10	20	40	60	80	100
Distance (D_2) (unit: mm)						
$W_2 \times D_2$						

What do you notice about the third row of the table?

Activity Three (small groups)

Repeat the experiment using a 20 gram weight for W1. Hang the weight about 30 cm from the fulcrum. Complete the following table using any weight/distance combinations that work. Try to guess what D2 will be before you actually hang each weight.

Weight (W_2) (unit: grams)	20					
Distance (D_2) (unit: mm)						
$W_2 \times D_2$						

At this point, you should have realized that in an inverse proportion, the two terms of the ratio (the numerator and denominator if the ratio is written as a fraction) always multiply to give the same value. Let's go back to painting your room. Suppose you think it will take you 6 hours of work when you work by yourself without stopping. We can write this as:

$$\frac{1}{6} \quad \begin{matrix}\text{(person)}\\ \text{(hours)}\end{matrix}$$

The two terms of the fraction (1 and 6) multiply to give you 6. With a friend, it should only take you 3 hours. When two people work, you can write

$\frac{2}{3}$ (persons) / (hours)

Again, the product of the two terms is 6. This relationship always holds in an inverse proportion so you can always solve an inverse proportion problem by looking for the number which is the product of the two terms.

Let's try one more example. Suppose Tom and Vickie are working together on a term paper. Tom, who can type 30 words per minute, can type the paper in 2.6 hours. If Vickie, who can type 22 words per minute, decides to help Tom by working on the second part of the paper, how long will it take the two of them working together to type the paper? We can write a fraction representing Tom working alone.

$\frac{30}{2.6}$ (words per minute) / (hours)

Multiply the two terms of the fraction together. What did you get?

When Tom and Vickie work together, their combined typing speed is 52 words per minute. Knowing that the typing speed multiplied by the number of hours must equal 78, find the time needed for Tom and Vickie to type the paper together.

Activity Four (entire class)

Like direct proportions, inverse proportions can also be solved using the cross-multiply and divide method. However, the proportion must be set up much differently to account for the fact that one term is increasing while the other is decreasing. You must (1) make a ratio of one type of term (persons, weight, etc.), (2) make a ratio of the second type of term (hours, distance, etc.), (3) invert one of the ratios (flip it upside down), and then (4) use the cross multiply and divide procedure for direct proportions. For example, we could make ratios of persons and hours to paint a room by doing the following:

$$\frac{1 \text{ person}}{2 \text{ persons}} \quad \text{and} \quad \frac{6 \text{ hours}}{X \text{ hours}}$$

We then invert the second ratio (although we could invert the first one instead) and make it equal to the first.

$$\frac{1}{2} = \frac{X}{6}$$

Cross multiplying we see that $2X = 6$ and $X = 3$.

Using the data from your last table, fill in D_2 for the 10 g weight in the table below. Then use the cross-multiply method to complete the table.

Weight (W_2) (unit: grams)	10	50	100	1	4	8
Distance (D_2) (unit: mm)						

Activity Five (small groups)

Answer the following using any appropriate method. Some of these problems involve direct proportions and some involve inverse proportions.

1. Three people can build a fence in 7 hours. How long will it take five people to complete the same job?

2. Emily rides her bicycle 4.5 hours at 12 miles per hour to get to her cousin's home. Riding a tandem (a bicycle built for two) with her sister, she can cover the distance in 3.6 hours. How fast do Emily and her sister ride on the tandem?

3. Julie and Jeremy can pick 16 bushels of apples in 3.5 hours. How long will it take to pick 16 bushels when Juan, Ellen, and George help out?

4. A home with 1,350 square feet sold for $87,750. Assuming that sale price depends on the number of square feet a home has, what would be the price of a home with 1,550 square feet?

5. A hose that delivers 220 gallons of water per hour can fill a pool in 16.5 hours. A second hose delivers 300 gallons of water per hour.
    a. Using only the second hose, how long would it take to fill the pool?

    b. Using both hoses together, how long would it take to fill the pool?

6. When water freezes, it's volume expands by 9%. How much water must freeze to form 545 cubic feet of ice?

Closing Discussion (entire class)

- How can you tell when a relationship between two numbers is a direct proportion, an inverse proportion, or not a proportion at all?

- Look back to question 2 in activity five. Compare the different ways that each group solved the problem. Did all groups get the same answer? Was one way faster? Which of the procedures used is easiest to remember?

- Think of an situation where two quantities both increase but are not in direct proportion. Explain.

- Think of a situation where one quantity goes up while another goes down but the two quantities are not an inverse proportion. Explain.

Lesson 8
OHM'S Law

Objective: To understand inverse proportions in terms of Ohm's law.

Materials:

- Power source
- Variable resistor
- Ohmmeter
- Ammeter
- Various batteries

Introduction

This lesson continues the discussion of inverse ratios by providing the opportunity to observe an inverse ratio in an electric circuit. You will work with Ohm's Law and the relationships between voltage, current and resistance. Although the experiments in this lesson use low voltages which are quite safe, be careful not to try these activities using more powerful power sources.

Activity One (small groups)

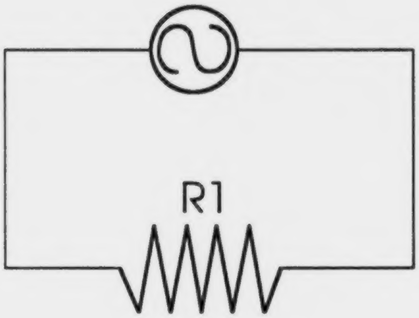
Let's start by examining a basic electrical circuit. We will first look at a diagram of the circuit, then at the circuit itself. Some special symbols are used to describe electrical circuit components. One component is the resistor, something which has the property of dissipating energy. Anything that uses electricity, from a light bulb to an electric motor, is a resistor. A resistor is represented by a zigzag or sawtooth shaped line. Each resistor in a circuit is identified with such a symbol and with a label consisting of a capital letter R followed by a number. The numbers are usually assigned in sequence beginning with one and thus the resistors in our circuits will be labeled R1. Resistors come in various sizes and shapes; some are fixed and some are variable. The amount of resistance a resistor provides is measured in Ohms. Fixed resistors have constant values and variable resistors can be adjusted to provide a variety of resistances. Sometimes variable resistors are called rheostats or potentiometers.

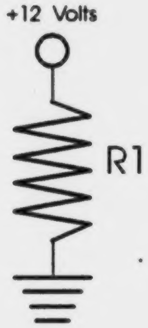
Every circuit must have a power source. What power source is involved when you use a vacuum cleaner? How about a flashlight? There are two general types of power source in common use: alternating current (AC) and direct current (DC). AC/DC is a rock band, not a power source! Household current in wall outlets in our country is generally 115 volts AC and batteries are usually between 1.5 and 9 volts DC. Car batteries are 12 volts. Look at several batteries to determine their voltage.

A circuit must be complete to be operative; that is there must be a continuous connection from one side of the power source through the components in the circuit and back to the other side of the power source. Electric plugs have two prongs because current must have a return path to the power source. Plugs used in AC house current sometimes have a third prong which is normally used as a ground. A ground is just an alternative path back to the source, making the electrical device safe even when the normal path back to the source is blocked.

DC must also have complete circuits. Sometimes there is a wire returning from the circuit to the battery; other times one side of the battery is connected to a common ground and the return side of the circuit is connected to this common ground. Cars generally use the frame as a common ground. This way only one wire is needed to stretch all the way from the battery to a component, such as a tail light. The side connected to the battery by this long wire is called the hot side. A relatively short wire is connected to the return side of the light and is run to a convenient point on the frame to complete the circuit. This side of the circuit is said to be connected to ground. The symbol for ground is something like a little upside down evergreen tree.

Two simple circuits follow. The one on the left uses AC; the one on the right DC. Other than that, they are equivalent.





We need to know how to measure resistance, current and voltage. An Ohmmeter measures the resistance of a resistor. We must disconnect the resistor from the circuit to get an accurate reading. Then connect the two leads from the meter to opposite ends of the resistor and observe the position of the needle on the meter. This reading is the resistance of the resistor. Current can only be measured in complete circuits, so the ammeter is placed between the resistor and the power source in our simple circuit. Current measurements are in amperes (amps). The power source voltage may be measured by placing the voltmeter's leads on opposite terminals or leads of the power source.

Our experiment will involve applying a voltage to a resistor and measuring the current flow through the resistor. We will change the resistance several times, then measure the new resistance and current. The power supply voltage will be measured before we start the experiment and is not expected to change. It is all right to measure the voltage periodically to verify that it hasn't changed. Can you think of real life situations in which voltages change?

Begin the experiment by measuring the power supply voltage and the resistance of R1. Record them in the table below. Complete the circuit and measure the current flow in the circuit with the ammeter. *Be careful not to put too much current through the circuit* *or you will damage the meter.* Record the current reading from your circuit on the same line as the voltage and resistance just measured. You should now have one row of the table filled in.

Break the circuit by disconnecting the resistor from the power source. Now adjust the resistor to a different value. Record this new resistance in the next table line. Reconnect the circuit and measure the current. Record the current next to the resistance. If voltage wasn't measured, put ditto marks in the voltage column; otherwise write in the voltage measured.

Repeat this process several times filling in your table with a variety of resistances and currents.

Voltage	Resistance	Current

When you have finished this part of the experiment, look closely at the data gathered. See if there are any patterns or relationships between values. What might they be? Can you write a formula that expresses this relationship? Give it a try.

Now let's test your formula. The next table is partially filled in. Use your formula to fill in the rest of the values. If your formula is correct, the computations should be very simple.

Voltage	Resistance	Current
100	100	
100		2
	4	3
12	6	
12		4

As you can see, resistance and current are inversely proportional! Remember that in inverse proportions, two terms always multiply to give a specific number. Which two terms multiply to give the third in electric circuits?

Activity Two (small groups)

Answer the following. Some involve direct proportions and some involve inverse proportions.

1. The voltage in a circuit is 115 volts and the resistance is 40 ohms. What is the current?

2. In another circuit, the current is 30 amps and the resistance is 6.5 ohms. A second resistor is added to the circuit giving a total resistance of 15 ohms in the circuit. What is the current after the second resistor has been added?

3. A third circuit has a voltage of 220 volts and a current of 12 amps. How much resistance must be added to reduce the current to 5 amps?

4. One way to estimate construction cost of a building is by the number of square feet the building will have. A house with 1250 square feet cost $75,000 to build. How much would it cost to build a house with 1750 square feet?

5. Some home circuits are designed to carry a maximum current of 20 amps. How much resistance is necessary to insure that a 20 amp circuit will not overload, assuming 115 volts of power?

6. A 15 amp circuit has a resistance of 90 ohms. What will be the current if the resistance is reduced to 60 ohms?

Closing Discussion Questions (entire class)

- A "short circuit" occurs when there is no resistor in a circuit and thus the only resistance is the minimal amount caused by the wires themselves. Assuming a household circuit is 115 volts, what happens to the current when there is very little resistance in a circuit, say 2 ohms or less?

- Problems 2 and 6 in activity two could have been solved by finding the product of the amperage and resistance or by using the invert and cross-multiply method for inverse proportions. Show how the problems could be done using both methods.

MODULE 2: MATHEMATICS

UNIT 2

SYSTEMS OF EQUATIONS

By

Peter Kloosterman, Indiana University, Bloomington
Thomas Benjey, Indiana University, Bloomington
Charles Emenaker, Indiana University, Bloomington
Joan Houston, Columbus East High School, Columbus
Richard Hurt, Bloomington North High School, Bloomington
Ross McKenna, Ben Davis High School, Indianapolis
Ronald Preston, Indiana University, Bloomington
Paola Sztajn, Indiana University, Bloomington

Abstract

Linear equations are used to describe the dimentions of pipes and washers, and a variety of procedures are presented for solving such equations.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

SYSTEMS OF EQUATIONS

Introduction

Systems of Equations is more advanced than Ratios and it contains less guidance for the teacher. This is particularly true in lessons seven and eight for which only outlines of activities have been provided. The unit is likely to be of greatest value at the end of a first-year course or during a second year course. Note, however, that the first two lessons involve writing and solving simple linear equations. They are intended for review and are easier than lessons three through eight. You may want to use these two lessons for review or by themselves during the first semester of a Tech Prep mathematics course. Alternatively, you may find that they are not necessary for your students.

Systems of Equations has fewer "hands-on" activities than Ratio. Unfortunately, there are some topics that are important from a mathematical perspective but have limited immediate application. Systems of equations appears to be such a topic. One of the reviewers of the unit suggested that we include applications of Kirchhoff's law by setting up electrical circuits for lesson 5 or 6. This seems like a reasonable laboratory activity that is worth pursuing. You may wish to have your students explore Kirchhoff's law and see if they can apply the concepts taught in this unit.

Lesson 1
Writing Linear Relations

Objective:

To understand the mathematical relationship between outside diameter, inside diameter, and wall thickness for various pipes and other cylinders.

Materials Needed:

short sections of pipe or hose of various diameters
vernier calipers or rulers capable of measuring to 1/32 of an inch

Introduction

In this lesson you will investigate the various dimensions of pipe and hose. Two dimensions that are frequently given for pipe are the outside diameter (OD) and the inside diameter (ID). The OD is the total width of the pipe. The ID is the width of the inside of the pipe. A third measurement that is important at times is the wall thickness. When and why would it be important to know each of these measurements?

Activity One (small groups)

Measure the OD, ID, and wall thickness on each piece of pipe your group has collected. You may even want to trade or share pieces of pipe with other groups to get a larger assortment. Within your group, discuss how you might measure the OD and ID to get an accurate measurement. Also discuss how you will accurately measure the wall thickness. How do you know each of these measurements will be accurate?

As you measure a piece of pipe, record the dimensions in the table on the next page. As you are measuring the sections of pipe, what are some ways you can double check the measurements?

HINT: You may want to number the pieces of pipe so you can keep track of which ones you have measured. One way to do this is to put a piece of masking tape on each pipe or hose and then write on the tape with a pen or marker.

Pipe Number	OD	ID	Wall Thickness

Activity Two (small groups)

Working with members of your group, can you find a pattern or relationship between the OD, ID, and wall thickness using the measurements you made in the first activity? Write this relationship in sentence form in the space below.

As a group, calculate the OD of a pipe that has an ID of 1 $^1/_2$ inches and a wall thickness of $^1/_4$ inch.

The OD of the pipe is ________ inches. Why is it important to include the label "inches?"

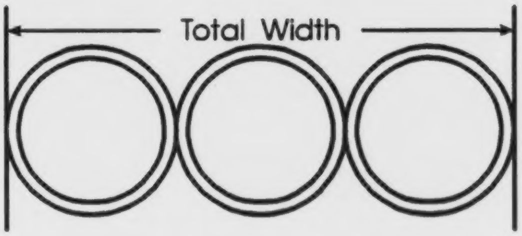
Suppose a pipe has an OD of 3 inches and a wall thickness of $^3/_8$ inches, what is the ID of the pipe?

The ID of the pipe is ____________________ . (Did you include the units label?)

Can you find the wall thickness of a pipe if it has an OD of 2 $^1/_2$ inches and an ID of 2 inches? What is the wall thickness? How can you prove to someone that the wall thickness is what you say it is?

Activity Three (small groups)

Suppose you were working with three pipes attached to each other as shown.



Write a sentence relating the total width of the pipe assembly to the ID and wall thickness.

Put three identical pieces of pipe together and measure the total width. Was your sentence accurate?

Closing Discussion Questions (entire class)

- What will happen to the wall thickness if the ID is increased and the OD remains constant?
- A bearing on a shaft is lubricated by oil flowing at a low pressure through a pipe to the bearing. If a larger volume of oil needs to be delivered to the bearing and the OD cannot be increased due to clearance problems, what can be done to increase the oil flow without increasing the oil pressure?
- In hot water heating systems, minerals accumulate on the inside of the pipes over a period of years. How will this affect the amount of hot water the system can deliver?
- Many people are concerned about the amount of cholesterol and fat in their diet. It is often the case that as a people eat more food with fat and cholesterol more plaque will build up on the inside of their blood vessels. How does this affect the flow of blood? How can this affect the heart? Why?
- Assuming you have completed the Tech Prep Ratio and Proportion Unit, recall what is meant by the term *direct proportion*. If we changed the number of pipes in the diagram in activity three, would the total width always be directly proportional to the outside diameter of the pipes? Will inside diameter always be directly proportional to total width? Is inside diameter directly proportional to outside diameter?

Lesson 2
Linear Equations

Objective:

To solve linear equations by guess and check as well as by algebraic techniques.

Materials needed:

3" x 5" index cards
pennies

Introduction

In the previous section we looked at the relationship between the OD, ID, and the wall thickness of pipe. In this section we will consider how to describe this relationship in terms of algebraic equations. We will also consider how to describe and then solve other problems.

Activity One (small groups)

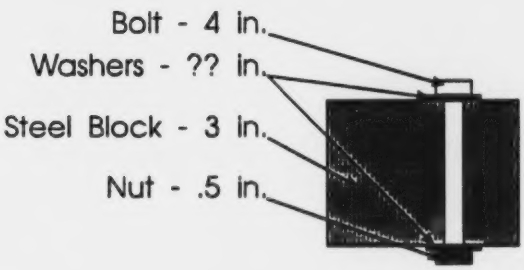
Look back to the relationship you found between the OD, ID and wall thickness of pipe in activity two of the last lesson. Copy your sentence or sentences in the space below.

How could this relationship be rewritten as an equation where the wall thickness is unknown, the OD is 3 $^1/_4$ inches and the ID is 2 $^3/_4$ inches? Write the equation below.

Check your equation using the measurements you made in lesson one. Are you able to find the wall thickness given only the ID and OD? If not, discuss with your group how you should change your equation to find the wall thickness.

Activity Two (small groups)

In the activities that follow we will need to be able to solve equations to find the value of the variable. One way to find the value of the variable is to guess and check to see if it works in the equation. For example, suppose you need to solve for the thickness of two washers in the situation pictured on the next page.



Notice in this situation the thickness of the steel block, the nut, and the two washers must add up to 4 inches, the length of the bolt since the bolt does not extend beyond the nut. This problem could be described as

Bolt Length = Steel block + Nut + 2 Washers.

This could be rewritten as an equation. Since we know all of the measurements except the washer thickness, we can include these in the equation. We don't know what size washers to use yet so we use a variable, W to represent the washer thickness. The equation can be written as

$$4 = 3 + {}^1/_2 + 2W$$

or, adding the 3 and the $^1/_2$ together,

$$4 = 3\,{}^1/_2 + 2W.$$

One way to find the thickness of the washers is to guess and check the value in the equation. If the value works we have the size we need; if it doesn't we can get information on the size of the next guess. For example, suppose we guess the washers need to be $^1/_2$ inch thick. Substituting $^1/_2$ into the right-hand side of the equation we get

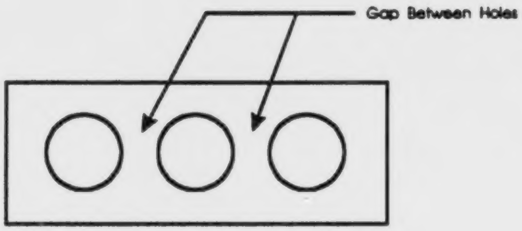
$$3\,{}^1/_2 + 2({}^1/_2) = 3\,{}^1/_2 + 1 = 4\,{}^1/_2 \text{ inches.}$$

Does this value work? If not, as a group decide how you should adjust it until you find the correct answer.

What washer thickness is needed? ___________ (Did you include units?)

Activity Three (small groups)

Let's consider another situation where a linear equation would be useful. Suppose a special motor mount needs to be designed. The mount needs to be 5 inches long and have three equally spaced $^3/_4$ inch holes. There also needs to be a 1 inch space on each end of the mount to allow for installation. A diagram of what the mount should look like is included below.



How much of a gap should be allowed between the holes?

Gap = ________ (Did you include units?)

HINT: You can model this motor mount using an index card and pennies. As a group, develop a sentence that describes how you could solve the problem. Write the sentence below.

Write this sentence as an equation. What will the variable represent in this equation?

As a group, solve for the variable by guessing and discussing what the next guess needs to be. If you wish, you may use the table on the next page to help keep track of your guesses.

Width of Gaps (Guess)	Total Width of Holes and Gaps

What size gap needs to be between each hole? ___________ (Did you include units?)

After finding the width of the gap between the holes, sketch a template on an index card using the gap width you found. (Be careful not to use pennies to draw the holes. Why?) Does it work? If not, discuss as a group why your solution did not work. Also discuss what needs to be done to find the solution and carry out your new plan. Does this new solution allow you to design the template?

Activity Four (small groups)

As a group develop an equation that describes the total width of three identical pipes in terms of their inside and outside diameters. (See activity three in lesson 1).

If the total width is 5 inches and the ID of each pipe is 1 $^1/_3$ inches, as a group determine the wall thickness using the guess and check method. A chart is included on the next page to help keep track of your guesses.

Guess	Resulting Right -Hand Side Value	Guess Too Large or Small

What is the wall thickness? ______________ (Did you include units?)

Activity Five (small groups)

Each of the above activities was solved using guess and check. Each of these problems could have also been solved algebraically. Let's take a look at how above activities could be solved algebraically.

In the last activity, the linear equation was

Total Width = 3 X ID + 6 X Wall Thickness.

To solve this equation, you first need to put the values you know into the equation. For example, you know that the total width is 5 inches and the ID of each pipe is 1 $^1/_3$ inches. Putting these values into the equation gives

$$5 = 3(1\ ^1/_3) + 6W.$$

The next step is to simplify both sides of the equation. In this equation, only the right side needs to be simplified. Use what you know about order of operations to simplify the right side. First, perform any operations inside of parentheses. In this case there is nothing to do inside the parentheses. After this you perform any multiplication or division operations that involve the parentheses. What would you do here?

Multiplying the 3 times the 1 $^1/_3$ gives 4, so the 3(1 $^1/_3$) can be replaced with 4 in the equation giving

$$5 = 4 + 6W$$

Once you have gotten rid of all parentheses, you want to get the variable term alone on one side of the equation. Here we can get the 6W alone on the right side of the equation by subtracting 4 from BOTH sides of the equation. Why is four the number we need to subtract?

At this point, the equation should be

$$5 - 4 = 4 - 4 + 6W$$

or

$$1 = 0 + 6W$$

$$1 = 6W.$$

We are trying to find the wall thickness W, not 6 times W. Therefore, we need to eliminate or cancel the 6 that W is multiplied by, leaving the W alone on the right side of the equation. To "undo" multiplying by 6, divide BOTH sides of the equation by 6.

$$\frac{1}{6} = \frac{6W}{6}$$

On the right side of the equation the 6's will "cancel." Why?

Once the 6's are cancelled on the right side, the equation that is left is

$$\frac{1}{6} = W$$

Now we know that the wall thickness, W, is $^1/_6$ of an inch. Did you guess this answer earlier? Should the two answers be the same?

In the second activity you were asked to guess the solution to the equation

$$4 = 3^1/_2 + 2W$$

where W = washer thickness. To solve this equation algebraically for the washer thickness, we follow the same ideas we used in the problem you just finished. Since there aren't any parentheses, what will you do first? Record the results of this step in the space below.

What should you do next? Do this step in the space below.

What thickness of washer should be used?
Is this the same thickness you decided on using guess and check?

If the thicknesses are not the same, as a group decide on the correct size washer to use. How do you know this is the correct size washer?

Correct washer size = ___________

In the third activity you needed to solve the equation

$$5 = 3\,({}^{3}/_{4}) + 2 + 2G$$

where G = gap between holes. Show the steps in solving the equation in the space below.

Is your answer the same as you guessed earlier?

If not, as a group decide what the correct gap size is and why the answers are different.

Correct gap size = ____________

Activity Six (small groups)

When drilling holes in plastic you need to be careful not to drill too quickly or the heat of the drill bit will melt the plastic. To keep from drilling to quickly, the number of revolutions of the bit per minute must be kept lower than it would be for drilling steel. As a result, the cutting speed of the drill will decrease. The cutting speed is the number of feet per minute the outer cutting edge of the bit travels. The equation for cutting speed is

$$C = \frac{3.14BR}{12}$$

where:C is the cutting speed of the bit in feet per minute,
B is the bit diameter in inches, and
R is the number of revolutions the bit turns per minute.

In order to keep up with the demand of production, you must set up a drill press with a $^{3}/_{4}$ inch bit at 650 rpm (revolutions per minute). The plastic will melt if the cutting speed of the outer edge of the bit exceeds 120 fpm (feet per minute). Is 650 rpm acceptable or should the number of revolutions be decreased and a second drill press be brought in? (Solve algebraically.)

Is 650 rpm acceptable? ________
Can the demand be met with one drill press? ________________

Using a $^{3}/_{4}$ inch bit, what is the maximum rpm for drilling this type of plastic?

Maximum rpm = ____________________ (What units will you use for this number?)

Closing Discussion Questions (entire class)

- What are some advantages of using the guess and check method?
- What are some disadvantages of using this method?
- What ideas do you have for other methods of solving these problems?
- Why was it important to include the units for each of your solutions?
- Should you ever get different solutions by using the algebraic and the guess and check methods? Why or why not?
- If you get different solutions using the two methods, what do you need to do to determine the correct solution?
- Suppose you are having difficulties solving an equation algebraically. What other way(s) can you solve the problem?
- In the formula for cutting speed, what does 3.14 stand for? Why do we need this number in the formula?
- In the formula for cutting speed, why is it necessary to divide by 12? How could we change the way numbers are entered into the formula so that it was not necessary to divide 3.14 by 12?

Lesson 3
Solving Break-Even Problems with Graphs

Objective:

To learn what the break-even point is and to be able to determine it graphically.

Materials Needed:

graph paper
ruler or straightedge

Introduction

Many times in life you will be presented with two or more ways to buy something or be billed for a service. The method of purchase you decide on may depend on the number of times you plan to use the service. For example, your phone company offers special long-distance rates to people who are willing to pay a membership fee. You will then need to decide if you will use the service enough to actually save money by joining.

In business, profit is important. (Without a profit, the company will go bankrupt!) An important consideration that a business will address before spending money on a project is the point when the income equals the total cost. It is at this point that the company can start to make a profit. The point where the income matches the costs is also called the break-even point. Once the income or revenues exceed the break-even point, the company can show a profit. If the income is less than the break-even point then the company loses money.

In working with break-even problems at least two equations will be involved, one that describes the costs and another that describes the income or savings. Break-even problems can be solved by graphing equations that represent the costs and income. The point of intersection of the two lines represents the point at which the costs and income (or savings) are equal, in other words the point at which the income has paid for all of the initial costs. This analysis can save you money as a consumer and provide important information on what is necessary for the company to pay the bills and eventually make a profit.

Activity One (small groups)

Your group is going to operate a concession stand at homecoming this year. You will need to spend $100.00 to rent equipment. The soft drinks will cost you 15 cents per serving. This price includes the cost of the drink, cup, and ice. If you plan to sell the drinks for 55 cents, how many will you need to sell to break even?

There are two equations normally involved in a break-even problem, one is the cost equation and the other is the income equation. As a group develop a verbal description of the cost. Write the description below.

Rewrite this description in the form of an equation. Make sure you state what your variables represent. (What quantities will you need to represent? What variables will you use?)

The next consideration is the income. As a group develop a verbal description for the income. Write the description in the space below.

Rewrite this description as an equation.

Graph both of the equations your group has developed on the graph below. (If necessary, review procedures for graphing with your group or teacher.)

Once both lines have been graphed, how will your group determine the break-even point? How many cups will you have to sell to break-even?

If you want to make a profit of $100.00, how many sales will you have to make beyond the break-even point?

How much money will you lose if you only sell 100 drinks?

Activity Two (small groups)

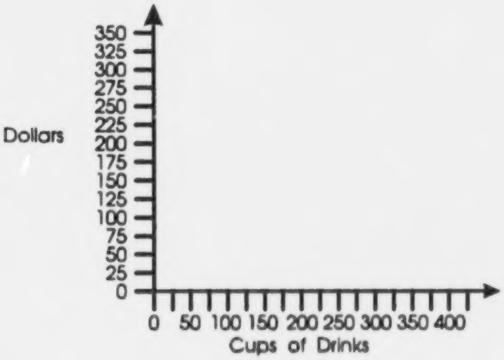
Suppose you go to a video store and are presented two different ways to rent videos. One way is to just rent the videos for $3.50 each. A second way is to join the video club at the store. The membership fee is $6.00. If you are a member you can rent videos for $2.75 each. How many videos will you need to rent before it will be to your advantage to join the video club? In other words, what is the break-even point for joining the video club?

What are the two choices you have for renting videos? As a group develop an equation that will describe the total cost involved for renting videos each way. Make sure you state what your variables represent.

Equation 1:

Equation 2:

As a group, make a graph with your graph paper to determine the break-even point. If your join the club, how many videos will you need to rent before you start to save money?



How much money would you save if you joined the club and rented 12 videos?

How much money would you lose if you joined the club and only rented 4 videos?

Optional Activity Three (small groups)

Your group is going to open a small shop. You want to offer copy service to attract more people to your shop. Contact a local business supply store and get information on the monthly rental fee on an inexpensive copy machine and the per copy cost. If you want to charge 10 cents per copy, how many copies will you need to make per month to reach the break-even point? Use graph paper to graph your cost and income equations.

Closing Discussion Questions (entire class)

- Look back at the first activity. If ticket sales indicate that 200 people will attend homecoming how many drinks will each person have to buy for your group to make $100 profit?
- How much will each person in the group make for the evening's work? Does this seem like a good business venture? Why or why not?
- What is the minimum number of people you would want to come to homecoming before deciding to operate the drink concession? Why this number of people?
- Other than using a graph, what are some ways you can check your answers in the first activity to be sure the break-even point has been correctly identified?
- What are the advantages of using a graph to solve break-even problems? What are the disadvantages?

Lesson 4
Solving Systems of Equations Graphically

Objective:
To solve systems of equations using graphs.

Materials needed:
graph paper
ruler or straight edge

Introduction

In the last lesson you saw how a system of equations (2 or more equations) can be used to help make decisions. In this section you will see other applications of systems of equations for making decisions.

Activity One (small groups)

You own the Speedy Lube Oil Change and have a contract with the Rust Bucket Car Rental to change the oil in their cars. They need to change oil in 30 of their compact and 45 of their full-sized vehicles. Each of the compact cars requires 4 quarts of oil and a PH8B oil filter. Each of the full-size cars requires 5 quarts of oil and a PH8B oil filter. Today you have a total of 194 quarts of oil and 41 PH8B oil filters on hand. How many of each type of car should you schedule for service today?

In solving problems like this, it is important to first identify what are called the constraints or limiting factors in the problem. One of the constraints is that you have only 41 oil filters on hand. What is the other constraint in this problem?

Each constraint needs to be described in the form of an equation. For example, one of the limits on materials in this problem is the number of oil filters available. Notice there are two ways the filters can be used, either on the compact or the full-sized cars. The number of each type of car that can be serviced can be varied. You can do 41 of the full-sized cars or some combination of the two sizes of cars. Let a variable, say C, represent the number of compact cars to be serviced and F the number of full-sized cars to be serviced. Since each car only uses one filter, the number of cars serviced should add up to the number of filters, in this case 41. As a group, write an equation that represents the total number of filters needed to service compact and full-sized cars.

The next equation will come from the second limiting factor, quarts of oil available. If the oil is changed in 8 compact cars, how many quarts of oil will be used?

If C represents the number of compact cars, how can the total amount of oil needed for C cars be represented algebraically?

How can the amount of oil used for F full-sized cars be represented?

How many quarts of oil are available total?

Write an equation that relates the total number of quarts of oil available to the number of quarts of oil required for each type of car.

At this point you have 2 equations, one for the oil filters used and the other for the oil used. Notice that both equations use the same variables, C for compact cars and F for full-sized cars. It is very important that all equations be written using the same variables. An easy way to identify the variables in the problem is to determine what you need to know. Here, we know the number of filters and the amount of oil available. What we don't know is the number of each type of car to service.

With the two equations determined you can solve the problem just like you did in the last lesson: graph each equation and determine where the graphs intersect. This point of intersection is the solution. Construct a graph to solve this problem.

How many compact cars should you service today? ____________

How many full-sized cars should you service today? ____________

You will need to finish the rest of the cars tomorrow. Determine the number of filters, quarts of oil, and hours of labor will you need to schedule for tomorrow to finish the rest of the cars. Each compact car takes 15 minutes of labor and each full-sized car 20 minutes of labor. (HINT: You can do this without creating new equations and graphing them.)

Number of filters needed for tomorrow = ____________

Number of quarts of oil needed for tomorrow = ____________

Number of hours of labor needed for tomorrow = ____________

If each person works an 8 hour shift, how many people will you need to schedule to work tomorrow? ___________

Activity Two (small groups)

You are the plant supervisor for the Tippie Canoe canoe manufacturer. The company is featuring two styles of canoes in an upcoming sporting goods show and needs to have a large number of each on hand to sell. One model, called the *River Runner*, requires 3 gallons of fiberglass for and 25 feet of mahogany trim for each canoe. A second model, called the *Backcountry Explorer*, requires 4 gallons of fiberglass and 32 feet of mahogany per canoe. If there are 83 gallons of fiberglass and 681 feet of mahogany trim in stock, how many of each type of canoe should be made?

As in the last problem, you first need to identify the constraints. List them below.

Each constrain or limiting factor will always result in an equation. The equation needs to be written in terms of the variables. What will the variables be in this problem? (HINT: What are you asked to determine?) List what you are asked to find or determine below. Assign each item a variable name like we did in the first problem. For example, R could be the number of River Runners you are going to make.

One of the restrictions is the amount of fiberglass available. If you make a River Runner, how much fiberglass will you need?

Suppose you make 5 River Runners, how much fiberglass will you need?

In the equation for fiberglass, what will you need to multiply R by to represent the total amount of fiberglass used to make River Runners?

What will you need to multiply the variable for Backcountry Explorers by to represent the total amount of fiberglass used to make these canoes?

How much should the fiberglass for both types of canoes add up to?

Write an equation for the amount of fiberglass used, in terms of the number of each type of canoe made.

As a group, determine the equation for the other restriction in the problem. Should you use the same or different variables for this equation?

Use a graph to solve the problem.

How many River Runners should you make today? _______

How many Backcountry Explorers should you make today? _______

As a group, decide how you can convince other groups that your solution is correct. Describe your strategy below.

Discuss your results with members of other groups to see if they arrived at the same solution. If different solutions were found, determine if both solutions are correct or if a mistake was made.

Activity Three (small groups)

As a group, solve the following problem:

You need to ship 31 hydraulic cylinders and 32 brake drums to a customer. You have two types of crates available. Due to differences in shape, the first type of crate can hold 1 hydraulic cylinder and 2 brake drums. The second type of crate can hold 3 hydraulic cylinders and 1 brake drum. How many of each type of crate should be used to ship the order?

List the restrictions you must meet in this problem.

List the variables in this problem.

Write an equation describing each of the restrictions using the variables you just listed.

As a group decide how you will solve the problem, then solve the problem.

Number of the first type of crate needed = _________

Number of the second type of crate needed = _________

How you can be sure this combination of crates will work?

Closing Discussion Questions (entire class)

- What are some advantages to solving the problems by graphing instead of guess and check?
- What were some problems you encountered using graphs to solve the problems?
- In a business setting, do you think graphing would be a good way to normally solve problems? Why or why not?

Lesson 5
Solving Systems of Equations By Substitution

Objective:

To be able to use the substitution method to solve systems of equations with two or three variables.

Materials needed:

none

Introduction

In the last lesson you used graphs to solve a system of equations. Graphs will work when you have two restrictions resulting in two equations. If there are more than two restrictions, you cannot solve the problem graphically. You probably also noticed that even when a graph is carefully made, at times it is difficult to read the solution. In this section we will learn a method of solving systems of equations that will work for any number of variables. This method also makes it easier to determine the exact solution.

Activity One (entire class or small groups)

In earlier lessons you were able to solve for the value of a variable if there was only one variable. This same idea will be used in this method. Let's look at how we would solve the Speedy Lube problem from Lesson 4 using substitution. The system of equations was

$$C + F = 41 \text{ (oil filters)}$$
$$4C + 5F = 194 \text{ (quarts of oil)}$$

By subtracting F from both sides of the first equation, we have

$$C + F = 41.$$
or
$$C = 41 - F.$$

This new equations tells us what C equals. Specifically, C is equivalent to 41 - F. When using the substitution method of solving two equations, we take an expression which gives one of the variables and replace that variable with the expression in the second equation. For example, because the first equation can be rewritten as $C = 41 - F$, we can write the equation for quarts of oil using 41 - F *in place of* C. When we make this substitution, we get

$$4(41 - F) + 5F = 194.$$

Multiplying the terms in the parentheses by 4 gives

$$164 - 4F + 5F = 194.$$

Notice at this point we have one equation and only one variable (F). We can solve this just like we did equations in earlier lessons. We want to isolate the variable F, so we need to subtract 164 from both sides.

$$164 - 164 - 4F + 5F = 194 - 164$$

Simplifying, we get

$$0 - 4F + 5F = 30.$$

Next we need to combine or add -4F + 5F. This gives F, so we know that

$$F = 30.$$

This solution tells us that 30 full-sized cars should be serviced today. We still need to know how many mid-sized cars need to be serviced. Calculate this number using any of the equations that have both C and F. For example, one of the original equations was

$$C + F = 41.$$

We know the value for F is 30, so we put this into the equation giving

$$C + 30 = 41$$

or

$$C = 11.$$

This tells us we should service 11 compact cars and 30 full-sized cars today.

Suppose, at the time when the original substitution was made, we had mistakenly substituted C = 41 - F into C + F = 41. What would have happened? Substituting M = 41 - F back into this equation would have given us

$$41 - F + F = 41$$

or

$$41 = 41.$$

In some cases you may get 0 = 0. *If this happens it is nothing to worry about;* just substitute your new way of writing the variable into the other equation. Here we would try substituting C = 41 - F into 4C + 5F = 194. Just keep in mind if you ever get 0 = 0 or you find that a number equals itself while using substitution, substitute the new way of writing the variable into the other equation.

Activity Two (entire class)

Let's work through a second situation where using the substitution method is useful. Consider the following problem.

You need to design a diet for a critical care patient. The patient needs to receive 5000 I.U. (international units) of vitamin A and 400 I.U. of vitamin D each day. The patient is to be fed two solutions. The first solution contains 150 I.U. of vitamin A and 20 I.U of vitamin D per ounce; the second solution contains 140 I.U. of vitamin A and 8 I.U. of vitamin D per ounce. How many ounces of each type of solution should be given to the patient each day?

To solve this problem, we first need to determine the constraints. The constraints in this case are the amounts of vitamins A and D to be given each day. Our equations will address the amount of vitamin A and the amount of vitamin D needed. The number of ounces of the two solutions that can be administered is what can be varied, so our variables will represent the amount of each solution that is given.

If we let F be the variable for the number of ounces of the first solution and S the variable for the number of ounces of the second solution, then the equation for the amount of vitamin A the patient receives can be written as

$$150F + 140S = 5000.$$

The equation for the amount of vitamin D the patient receives can be written as

$$20F + 8S = 400.$$

Does these two equations make sense? Talk it over.

Now that we have our equations, we can use the substitution method to solve the problem. First we need to solve for one of the variables. So that we work with smaller numbers let's use the second equation and solve for S. (We could use either equation and solve for either variable, but the numbers are smaller in the second equation. This will make the job a little easier.)

To solve for S we need to get the 8S on the left hand side by itself. This means that we need to subtract 20F from both sides.

$$20F - 20F + 8S = 400 - 20F$$

or

$$0 + 8S = 400 - 20F$$

giving,

$$8S = 400 - 20F.$$

Notice we do not have S by itself, it is still multiplied by 8. To eliminate the 8 from the left hand side we will divide both sides by 8. Keep in mind that EACH term on the right hand side needs to be divided by 8.

$$\frac{8S}{8} = \frac{400}{8} - \frac{20F}{8}$$

This equation can be simplified to give

$$S = 50 - (^5/_2)\ F.$$

The new equation tells us that where ever we see S in an equation we can replace it with the expression $50 - (^5/_2)\ F$. We used the second equation to obtain this way of rewriting S, so we need to substitute into the first equation. What would happen if we substituted it into the second equation? When we substitute it into the first equation we get

$$150F + 140(50 - (^5/_2)F) = 5000.$$

At this point we need to be very careful in simplifying. *Each* term in the parentheses needs to be multiplied by 140. When we multiply each term in the parentheses by 140 we get

$$150F + 140(50) - 140(^5/_2)F = 5000$$

or

$$150F + 7000 - 350F = 5000.$$

In order to isolate the term with F we need to get rid of the 7000 on the left hand side. Subtracting 7000 from *both* sides, we get

$$150F + 7000 - 7000 - 350F = 5000 - 7000$$

or

$$150F + 0 - 350F = -2000$$

Now the two terms with F are added together, giving

$$-200F = -2000.$$

To isolate F, we need to eliminate the -200 from the left hand side. Dividing both sides by -200 gives

$$\frac{-200F}{-200} = \frac{-2000}{-200}$$

Simplifying, we get

$$F = 10.$$

Notice that F is positive. Would it make sense if F were equal to a negative number? Why or why not?

At this point, we know that the patient needs to receive 10 ounces of the first solution each day. We need to determine how many ounces of the second solution to give to the patient. This can be done by using the fact that

$$S = 50 - (^5/_2)F.$$

We know that F = 10, so we substitute this value into the equation for S and get

$$S = 50 - (^5/_2)10$$

or

$$S = 50 - 25$$

or

$$S = 25.$$

In order to meet the patient's nutritional needs, we need to give the person 10 ounces of the first solution and 25 ounces of the second solution each day.
How can you check your to be sure that the patient is receiving the correct dosages?

Optional Activity (entire class)

In some problems there will be more than two equations and variables. Problems with more than two equations and variables are solved in the same fashion, they just take longer and require greater care in computation.

Suppose we had a problem that resulted in the following set of equations.

$$3A + 2B + C = 23$$
$$2A + 3B + 4C = 42$$
$$4A + B + C = 25$$

We solve this set of equations in the same way we did the last two problems. The only difference is that it will take longer. In the last two problems we did a substitution to eliminate one of the variables. In this problem we will need to do two substitutions to eliminate two of the variables. As before, once an equation is used to rewrite a variable *do not* make any substitutions into it. Although we can start with any of the three variables, C is not multiplied by anything in the first equation and thus rewriting equation one to get C by itself should be fairly easy. Using the first equation we can subtract 3A from both sides to get

$$3A - 3A + 2B + C = 23 - 3A$$
or
$$2B + C = 23 - 3A.$$

Next we need to eliminate the 2B from the left hand side by subtracting it from both sides of the equation.

$$2B - 2B + C = 23 - 3A - 2B$$
or
$$C = 23 - 3A - 2B$$

Because $C = 23 - 3A - 2B$, we can take this new way of writing C and substitute it into both of the other equations. Start by substituting into the second equation.

$$2A + 3B + 4(23 - 3A - 2B) = 42$$
or
$$2A + 3B + 92 - 12A - 8B = 42$$

Simplifying, we get

$$-10A - 5B + 92 = 42.$$

Subtracting 92 from both sides gives

$$-10A - 5B + 92 - 92 = 42 - 92$$
or
$$-10A - 5B = -50.$$

Notice that each of the coefficients is divisible by -5. Dividing each term by - 5 it will make the equation easier to work with.

$$\frac{-10A}{-5} - \frac{5B}{-5} = \frac{-50}{-5}$$

or

$$2A + B = 10$$

Remember this new equation because will need it later. First, we need to do the substitution into the third original equation. Once again we will substitute 23 - 3A - 2B for C. The third equation was 4A + B + C = 25. Substituting for C gives

$$4A + B + (23 - 3A - 2B) = 25$$

or

$$4A + B + 23 - 3A - 2B = 25.$$

Combining like terms gives

$$A - B + 23 = 25$$

or

$$A - B = 2.$$

We now have two new equations with just two variables. These equations are

$$2A + B = 10$$

and

$$A - B = 2.$$

At this point, we are in the same position as we were when we started the first two problems in this lesson. We have two equations and two variables. To solve, we need to rewrite one of the variables. Let's rewrite B using the first equation. (As always, we could have done either of the variables in either of the equations.) We will need to subtract 2A from both sides of the equation yielding

$$2A - 2A + B = 10 - 2A$$

or

$$B = 10 - 2A.$$

We can then substitute this value for B into the other equation we just found, A - B = 2. Doing this gives

$$A - (10 - 2A) = 2$$

or

$$A - 10 + 2A = 2.$$

This simplifies to

$$3A - 10 = 2$$
or
$$3A = 12.$$

Dividing both sides of the equation by 3 gives

$$A = 4.$$

To find B we substitute the value for A into

$$B = 10 - 2A$$
giving
$$B = 10 - 2(4)$$
or
$$B = 2.$$

Because we know the values for both A and B, we can use these to substitute back into the equation, $C = 23 - 3A - 2B$.

$$C = 23 - 3(4) - 2(2)$$
or
$$C = 23 - 12 - 4.$$

This simplifies to

$$C = 11 - 4$$
or
$$C = 7.$$

To check our answers to see if they are correct, substitute $A = 4$, $B = 2$, and $C = 7$ back into the original equations. In the space below, show that these values work in all three equations.

Activity Three (small groups)

As a group, solve the three systems of equations given below. *Be sure to check your solutions by substituting the values you obtain back into the original system of equations.*

System 1:
$$\begin{aligned} 3X + 2Y &= 28 \\ X + 3Y &= 21 \end{aligned}$$

System 2:

$$\begin{aligned} 3M + 2N &= 24 \\ 5M + N &= 26 \end{aligned}$$

System 3 (optional):

$$\begin{aligned} 2D + E + 3J &= 37 \\ D + 2E + 2J &= 30 \\ 2D + 2E - J &= 10 \end{aligned}$$

Closing Discussion Questions (entire class)

- What are some advantages and disadvantages of using the substitution method instead of the graphing method to solve a problem?

- When using the substitution method, where you are most likely to make mistakes? How can you decrease the likelihood of making mistakes at these points?

- When solving problems by graphing, each variable is represented by an axis on the graph. What problem(s) would there be in using a graph to solve a problem with 3 or more variables?

- In the first activity we found that $F = 30$. What would have happened if you would have substituted this into the original equation $4M + 5F = 194$?

Lesson 6
Solving Systems of Equations by Addition of Equations

Objective:
To learn how to solve systems of equations using addition of equations.

Materials needed:
calculator
graph paper

Introduction

You have learned how to solve systems of equations using graphing and substitution. In some cases it is useful to have several methods of solution available as one method will be easier to use than the others. In addition, if you forget one method, you can always use another.

In this lesson, we will learn a third method of solution for systems of equations. This method, adding equations, will be useful in solving systems where there are more than two variables and equations involved. An example of a situation where three equations and variables are involved will be considered.

Activity One (entire class)

First we will look at a simple system of equations to see how this method is applied. Consider the system below.

$$X + Y = 7$$
$$2X + 3Y = 19$$

When using the addition method for solving a system of equations, we must multiply one or more equations by various numbers. It is important to realize that multiplying *all* the terms in equation by a number does not change the line that the equation represents. For example, if we graphed $X + Y = 7$ and then multiplied the equation by -3 and graphed the new equation we would get the same line in both cases. Let's try it. First you will need to multiply the equation by -3. Multiplying by -3 gives

$$(-3)\,X + (-3)\,Y = (-3)\,7$$
or
$$-3X - 3Y = -21.$$

Graph $X + Y = 7$ and $-3X - 3Y = -21$ on graph paper. Did you get the same line both times? Is there ever a situation where multiplying an equation by a number will change the graph of the line the equation represents?

Let's step through the solution to the two equations we were given. First we will want to eliminate one of the variables. In this case we will eliminate the X. We could have just as easily eliminated the Y. Later you will see how to decide which variable to eliminate. We will use the first equation to eliminate the X in the second equation. We can eliminate the X by multiplying the first equation by -2 and then adding this new equation to the second equation. For example,

$$(-2)\,X + (-2)\,Y = (-2)\,7$$

or

$$-2X - 2Y = -14.$$

What happened to the "+" sign in front of the Y when we multiplied by -2? Next we add this new equation to the second original equation.

$$\begin{array}{r} 2X + 3Y = 19 \\ \underline{-2X - 2Y = -14} \\ 0X + Y = 5 \end{array}$$

This new equation simplifies to Y = 5. Note that when we added the equations together, it was much like adding the same number to both sides of an equation. For example, we can always add -14 to both sides of an equation and still have a valid equation. In this case, we added -14 to one side of the equation but it was acceptable to add (-2X - 2Y) to the other side because it was equal to -14.

As we now know the value of one of the variables, we can proceed as we did when we solved equations by substitution. Substitute the value for Y into one of the original equations to find the value for X. Let's substitute it into the first original equation since it will be easier to solve.

$$X + 5 = 7$$

or

$$X = 2$$

From this you can see that X = 2 and Y = 5.

Activity Two (entire class or small groups)

Let's use the addition method to solve the Speedy Lube problem from Lesson 4. The original equations were

$$\begin{array}{c} C + F = 41 \\ 4C + 5F = 194. \end{array}$$

In this situation we can use the first equation to eliminate a variable in the second equation. Suppose you wanted to solve the second equation for F. (Actually, either variable could be solved for with equal ease in this case.) If you are going to solve for F this means that the C needs to be eliminated. What
will you need to multiply the first equation by to eliminate the 4C in the second equation?

Multiply the first equation by this number and record the result in the space below.

Next, add this new equation to the original second equation. Record your work in the space below.

What value do you get for F? ___________

Does this match the value you obtained in Lesson 4? Should it? Why?

Substitute the value for F into one of the original equations and solve for C. Record your work in the space below.

What value do you get for C? ___________

Does this match the value you obtained in Lesson 4? Should it? Why?

As a group decide how can you check your solution to be sure that it is correct. Check your solution.

Activity Three (entire class or small groups)

Because one of the equations in each of the preceding problems had coefficients of one for both of the variables, it was easy to decide what to multiply the equation by to eliminate a variable in the other equation. In this activity we will consider how we need to handle a situation where none of the coefficients has a value of one. We will use the following system of equations.

$$2X + 3Y = 24$$
$$3X + 5Y = 38$$

In cases like this, we need to focus on one variable and determine what to multiply each equation by to eliminate that variable. If you are not sure what to multiply by, you will always be successful if you multiply the first equation by the coefficient in the second equation and the second equation by the negative of the coefficient in the first equation. For example, let's eliminate the X's. Multiply the first equation by 3, the coefficient of X in the second equation and we will multiply the second equation by -2, the negative of the coefficient in the first equation. This procedure gives produces

$$\begin{gathered}(3)\,2X + (3)\,3Y = (3)\,24\\(-2)\,3X + (-2)\,5Y = (-2)\,38\end{gathered}$$

or

$$\begin{gathered}6X + 9Y = 72\\-6X - 10Y = -76.\end{gathered}$$

The next step is to add the two equations giving

$$\begin{array}{c}6X + 9Y = 72\\\underline{-6X - 10Y = -76}\\0X \; - Y = -4\end{array}$$

This last equation, $-Y = -4$, simplifies to give $Y = 4$. This value of Y can then be substituted into one of the original equations to find X.

$$\begin{gathered}2X + 3(4) = 24\\\text{or}\\2X + 12 = 24.\end{gathered}$$

Solving for X we find that $X = 6$. Check this solution to be sure it is correct.

Activity Four (small groups)

As a group, solve the system given below using the method of simultaneous solution. If you get lost, look back to the problems you have just completed.

$$\begin{gathered}2X + 4Y = 42\\5X + 2Y = 57\end{gathered}$$

Which variable will you eliminate?

To eliminate this variable, what number will you use to multiply the first equation? Carry this multiplication out in the space below.

What number will you use to multiply the second equation? Perform this multiplication in the space below.

What do you do after both equations have been multiplied? Show this step.

At this point your group should have the value of one of the variables. Find the value of the other variable.

As a group decide how you will check your solution. Check it in the space below. Compare your solution with other groups' solutions. If the solutions do not match, as a group decide how you will determine the correct solution.

Activity Five (small groups)

As a group, solve the problem below using the addition method for solving a system of equations.

Your car is quickly rusting into a heap of spare parts. In order to stop it from rusting any further, you want to apply two types of rust treatment. One treatment is designed for exposed surfaces and the other treatment is designed for inner panels where there is some protection. There are two rust prevention packages you are considering using. One is Rust-No-More and the other is End-Da-Rust. In the Rust-No-More package you get a 16 ounce spray can of exterior protectant and a 12 ounce can of interior panel protectant. In the End-Da-Rust package you get a 12 ounce spray can of exterior protectant and a 15 ounce can of interior panel protectant. You figure it is going to take 72 ounces of the exterior protectant and 66 ounces of the interior panel protectant to hold the car together for another year. How many of each package should you buy to get 72 ounces of exterior and 66 ounces of interior protectant?

As a group, list in the space below, the equations that describe this problem.

Which variable are you going to eliminate?

What will each equation need to be multiplied by to eliminate this variable?

Carry out the multiplication and complete the problem in the space below.

What value did you get for one of the variables? ___________

Find the value of the second variable.

What value did you get for the second variable? ___________

How many packages of Rust-No-More do you need to buy? ___________

How many packages of End-Da-Rust do you need to buy? ___________

Check your solution to be sure you will get the amounts of exterior and interior treatment that you actually need.

Optional Activity (entire class)

In this activity we will step through the process of solving a system of three variables and three equations using the addition method. Consider the system

$$\begin{array}{r} X + 2Y + 3Z = 35 \\ 2X + 3Y + 2Z = 41 \\ 3X + 2Y + 4Z = 55 \end{array}$$

When solving a system with three equations, we use one of the equations to eliminate the same variable in the other two equations. In this case, let's use the first equation to eliminate the X in the other two equations. The X was chosen because it has a coefficient of one which makes multiplying very easy.

To eliminate the 2X in the second equation, we multiply the first equation by -2 and add it to the second equation. This produces

$$\begin{array}{c} 2X + 3Y + 2Z = 41 \\ \underline{-2X - 4Y - 6Z = -70} \\ 0X - Y - 4Z = -29 \\ \text{or} \\ -Y - 4Z = -29. \end{array}$$

Next we multiply the first equation by -3 and add it to the third equation. This produces

$$\begin{array}{c} 3X + 2Y + 4Z = 55 \\ \underline{-3X - 6Y - 9Z = -105} \\ 0X - 4Y - 5Z = -50 \\ \text{or} \\ -4Y - 5Z = -50. \end{array}$$

At this point we have two equations and two variables. This is the same situation we are used to seeing from the first five activities. We will work with these two equations, solving them in the same way we did in the earlier exercises. The equations are

$$\begin{array}{r} -Y - 4Z = -29 \\ -4Y - 5Z = -50. \end{array}$$

Which variable will be easier to eliminate in this case?

Notice if we multiply the first equation by -4 and add it to the second equation the Y's will be eliminated, leaving just Z. Multiplying the first equation by -4 and adding it to the second equation produces

$$\begin{array}{r} -4Y - 5Z = -50 \\ \underline{4Y + 16Z = 116} \\ 0Y + 11Z = 66 \end{array}$$

This new equation will simplify to give

$$11Z = 66$$
or
$$Z = 6.$$

Substituting this value for Z back into one of the two equations with two variables, we can find the value for Y.

$$-Y - 4(6) = -29$$
or
$$-Y - 24 = -29.$$

Simplifying gives

$$-Y = -5$$
or
$$Y = 5.$$

Because we now have values for both Y and Z, those values can be substituted back into one of the original three equations to find the value of X. Using the first equation, we get

$$X + 2(5) + 3(6) = 35$$
or
$$X + 10 + 18 = 35.$$

Simplifying this equation gives $X = 7$. At this point we have values for all three variables. We can check to be sure that these values are correct by substituting them back into the three original equations. If they work in all three equations, then the solution is correct. Check the solution in the three original equations in the space provided below.

Activity Six (small groups or individually)

Solve the following systems using the addition method.

1) $4T + 3J = 42$
$6T + 5J = 64$

3) $4C + 3F = 26$
$C + 2F = 9$

2) $2P + 7Q = 42$
$3P + 2Q = 29$

4) $3K + 4R = 41$
$2K + 9R = 78$

5) (optional)

$$\begin{aligned} 2X + 5Y + Z &= 20 \\ 3X + 2Y + 3Z &= 38 \\ 4X + Y + 3Z &= 40 \end{aligned}$$

Class Discussion Questions (entire class)

What do you need to take into consideration when deciding on a variable to eliminate?

- In Activity Three you were told to multiply one of the equations by the negative of the coefficient in the other equation. Why do you need to multiply by the negative?

- In Activity Three, the following statement was made: "If you are not sure what to multiply by, you will always be successful if you multiply the first equation by the coefficient in the second equation and the second equation by the negative of the coefficient in the first equation." Why will this procedure always work?

- Suppose you have the system below to solve and want to eliminate the X. Do you really need to multiply the second equation by 15 and the first equation by -30? What else could you do to eliminate the X?

$$\begin{aligned} 15X + 8Y &= 54 \\ 30X + Y &= 63 \end{aligned}$$

- Which method(s) would be best to use if you must get a precise solution to a system of equations? Why?

- Suppose you are given a system of equations with either very large or very small numbers. Would this affect your choice of a solution method? Why or why not?

Lesson 7 (Optional)
Determining the Break-Even Point of a Small Business

Objective:

To analyze the needs of starting and running a small business, and to use this information to determine the break-even point of the business.

Materials needed:

will vary with projects

Introduction

Whenever a business person thinks of starting a new business an important point of consideration is the break-even point. It is important to know how much business and time are required to recover the initial outlay of capital. With this information a decision can then be made as to whether the business venture should be pursued. In this project your group will be asked to determine the break-even point of starting a small lawn care business.

Activity (small groups)

Your group is going to start a small lawn care business. You will need to determine the amount of money needed to get the business started, then how long it will take to reach the break-even point. With this information your group will then need to decide if it is worth pursuing this venture.

NOTE: If some other business is of greater interest to the group, determine the break-even point of this other business.

Discuss the costs for starting your business. At a minimum, you will need to take into account the cost of a mower, weed eater, gas cans for the mower and weed eater (they may use different types of gas), transportation, advertising, oil, gas, and labor. If possible, find exact costs. Where you cannot find exact costs, use estimates.

Write equations to represent each of your costs. Purchase of equipment is a simple one time cost, but supplies such as gas and transportation depend on the amount of time you actually are mowing. You will need to determine how much you will charge per hour. Solve the equations you write to determine the number of hours you need to work to break even. You can use any of the methods that have been covered in this unit.

How many jobs per week does this number of hours of labor represent if you want to break even in a month? How many jobs are needed to earn $200 in a month?

Lesson 8 (Optional)
Determining the Break-Even Point of a Small Business If Employees Are Involved

Objective:

To determine the break-even point when the additional constraint of an employee is introduced.

Materials needed

varies with the projects

Introduction

In this lesson you will consider the break-even point of the business you set up in Lesson 7. This time, you will analyze the business potential with employees that must be paid.

Activity (small groups)

As a group, determine the break-even point of the business you considered in Lesson 7 with two employees who each work for $4.50 an hour. You will also help mow, so you will need to purchase additional equipment and include this in your costs. Because you are going to split the work, you will need to determine who is going to do what jobs.

MODULE 3: SCIENCE

INTRODUCTORY COMMENTS FOR TEACHERS

By

Mary B. Nakhleh
Assistant Profesor of Science Education
Purdue University

Denise Briner
Chemistry Teacher
Columbus North High School

Jody Duncan
Physical Science Teacher
Bloomington High School South

William Lumbley
Department Chairperson for Science
Bloomington High School South

Richard Mitchell
Research Assistant
Department of Chemistry
Purdue University

Abstract

These introductory remarks describe the units and list the equipment needed for three levels of technology utilization.

Indiana Tech Prep Training Manual: Division II
Sponsored by
The Indiana Department of Education
Project # 92S-4762

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

Science Module
INTRODUCTORY COMMENTS

Overview

The following units have been created to function as guides for the science teacher who is new to Tech Prep. All of the objectives have been identified as to stage of technology (High, Medium or Low) utilization. These units demonstrate that it is possible to teach Tech Prep without having the computers and related equipment that many of the pilot schools were provided to initiate their Tech Prep programs. Tech Prep is more than a way of integrating technology into a classroom. Tech Prep requires a new approach to teaching and requires the teacher to function as a professional.

Implementation

The units in this module are not "cookbook" approaches to lessons that a teacher can just pick up and use. No effort has been made to make them in that vein. The developers of these units are practicing teachers who realize that each teacher has different attributes that will cause them to use these materials differently. That is not only expected, it is encouraged. Tech Prep teachers must be comfortable with the methodologies they employ in their classrooms. Therefore, Tech Prep science teachers are expected to adapt each activity to their stage of implementation. *However, any stage other than high utilization of technology is still short of Tech Prep's goal.* The goal is to utilize technology to provide our students with the highest level of technological preparation.

Notes about the Units

These units demonstrate how some topics have been successfully integrated into Tech Prep science curricula. These units have been tested in the classroom and have worked for at least one teacher on the writing team. Adjust these units, and those which you will create, to your and your students' optimal learning situation.

There are, however, things that you should note in these units. For instance, you will find that some of the activities are not "traditional" activities. Tech Prep is not designed to be traditional; it is designed to be real world. In meeting these design requirements, activities which are "real world" to your students have been included and should not be taken for granted. Activities such as listening to music and drawing meaning from the recording are "real world" to students. Therefore, these activities have been included in various units as a springboard to discussing a scientific/technological topic.

Traditional lesson plans would probably not include watching a clip from "The Terminator" to introduce a unit, but Tech Prep lesson plans might use the film to start the unit with what the learner already knows and build from that point. These activities are highly motivating to students and they contribute to the high level of interest that Tech Prep students exhibit toward their curriculum. Tech Prep offers you an opportunity to express your individual creativity in the lessons that your students experience.

Evaluation

Specific evaluation procedures have not been given for each of the following units.

This is an independent decision that individual teachers must make, and their choices will reflect their philosophy of teaching and learning. We caution you, however, to keep in mind the purpose of Tech Prep and how it differs from traditional learning formats. Tech Prep is not interested in requiring students to learn individualized bits of information. Tech Prep seeks to develop critical thinkers and good problem solvers. To this end, the goal is a synthesis of group work, group evaluation, and a resulting product. The evaluation method that you use should reflect that goal.

Therefore, individual quizzes and exams might perform a lesser role in evaluation than in your previous teaching. Additionally, it may be valuable for students to keep a journal of their activities and what they perceive they have learned from these activities. Class participation, as seen in group work and related interactions, may become a more important source of information for evaluation purposes. Whatever methods of evaluation you employ, you should remember that a major purpose of a Tech Prep evaluation is to help students assess their progress toward becoming good problem solvers and group participants.

Science Unit Preview

Using the units. The following units have been used by Tech Prep teachers. Two of the units, "Robotics" and "Wave Motion and Light", were used in physical science classes taught to ninth graders in a Tech Prep program. The "Microscope Investigation" unit was used in a Tech Prep biology course. The "Spectrophotometry" unit was used in a Tech Prep Chemistry course. The units could be adapted to many different levels and situations. For instance, the robotics unit could easily lend itself to a Tech Prep Physics course, wherein the programming and project designs would be expected to be significantly more advanced.

We provide here a list of the equipment and software that have been used in teaching these units. Again, not every school will have this equipment, nor is it our intent to suggest that they must have it initially.

Equipment & Software for Units
IBM 286-30 computers
ESHED Scorbot Robot Model 3
Leggo kits
IBM Personal Science Labs (motion, heat, light)
Vernier Software (Graphical Analysis, Frequency meter, Precision timer)
IBM Scientific Reasoning (distance, graphs, speed, electricity, light)
Microsoft Works
Linkway
Videomicroscope
Video tapes on robotics, light, and microscopy. *For further information on the video tapes listed in this unit, contact Jodie Duncan at 812-330-7714 x 544.*

MODULE 3: SCIENCE

UNITS 1, 2, AND 3

By

Mary B. Nakhleh
Assistant Profesor of Science Education
Purdue University

Denise Briner
Chemistry Teacher
Columbus North High School

Jodie Duncan
Physical Science Teacher
Bloomington South High School

William Lumbley
Science Teacher
Bloomington North High School

Richard Mitchell
Research Assistant
Department of Chemistry
Purdue University

Abstract

Units on Robotics, Wave Motion and Light; and Microscope Investigations.

Indiana Tech Prep Training Manual: Division II
Sponsored by
The Indiana Department of Education
Project # 92S-4762

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

UNIT I: ROBOTICS

Unit Objectives by Stage of Technology

1. To gain an awareness of the role of technology in society. (L,M,H)

2. To gain an awareness of the role of robotics in society. (M,H)

3. To introduce the current uses of robotics in business and industry. (L,M,H)

4. To introduce the types of robots, robotic systems and basic programming of robots. (M,H)

5. To demonstrate the repeatability of robotic movement through programming specific tasks. (L,M,H)

6. To apply problem solving and programming skills with Scorbot to an individual project. (H)

7. To observe uses of technology and robotics in local industries.(L,M,H)

8. To explore the future of robotics. (L,M,H)

Activity for Objective 1:
A. Listen to several songs that reflect some of the emotions of people adjusting to technological advancements in society. Ask students to suggest songs with this theme.

Activity for Objective 2:
A. Make a list of activities that robots perform. Also list people's reactions and feelings toward the future of robotics in industry. Class sharing and discussion will follow.

Activity for Objective 3:
A. View video, "The Robotic Revolution".

Activity for Objective 4:
A. Use of robot software (Scorbot level 1-2).

Activity for Objective 5:
A. Write a program involving the sequencing of simple robot movements.

Activity for Objective 6:
A. Student creates a project of their own design using Scorbot Robot and Scorbot Level 3 language.

Activity for Objective 7:
A. Visit United Technologies or other local technology firm to view uses of technology.

Activity for Objective 8:
A. Write or read a science fiction short story with a theme projecting a robotic world. Suggestion: read Isaac Asimov's science fiction books on robotics.

UNIT II: WAVE MOTION AND LIGHT

Unit Objectives by Stage of Technology:

1. To gain an appreciation of the range of frequencies in the electromagnetic spectrum and the narrow range in the visible spectrum. (L,M,H)

2. To gain an appreciation of the range of frequencies in the electromagnetic spectrum and narrow range in the visible spectrum. (L,M,H)

3. To understand the history of the measurement of the speed of light. (L,M,H)

4. To understand wave properties, nodes, anti-nodes, amplitude, frequency, wavelength, and velocity of propagation. (L,M,H)

5. To become familiar with wave phenomena manifested in electromagnetic waves, such as superposition, reflection, refraction and diffraction. (L,M,H)

6. To observe wave phenomena in visible electromagnetic radiation in the laboratory. (H)

7 .To pose and answer questions about wave phenomena in the visible spectrum such as "What is the speed of light in a medium other than air?" and "What is the index of refraction of various liquids?". (M,H)

8. To gain an appreciation of how the speed of light make electromagnetic radiation ideal for communications. (L,M,H)

9. To suppose what the future holds for communications with electromagnetic radiation. (L,M,H)

Activity for Objective 1:

A. Relate the visible frequencies of light (red light at 20 Hz, violet at 20,000 Hz) to the range of sounds that the human ear can hear. Then expand the discussion from the visible to electromagnetic spectrum, from infrared to ultraviolet frequencies.

Activity for Objective 2:

A. Class discussion regarding the uses for the frequencies of the electromagnetic spectrum below the visible and above the visible range. Why is the human eye sensitive only to visible? Physiologically are we sensitive to other frequencies? That is, does our body react to other frequencies present in sunlight? (tanning & skin cancer, Vitamin-D)

Activity for Objective 3:

A. Watch the video "Light". Discuss what motivated experimenters to determine the speed of light and how the experimenters must have felt about centuries of failure in attempting to determine the speed of light.

Activity for Objective 4 & 5:

A. Discussion and demonstration.

Activity for Objective 6:

A. Use laser to measure speed of light, reflection of light, refraction of visible light and diffraction of visible light.

Activity for Objective 7:

A. Find the index of refraction and the speed of light in various liquids using refraction tanks.

Activity for Objective 8:

A. Have students report on communications with electromagnetic radiation. Groups report on: radio band communication, microwave band communications, geosynchronous satellite communication, visible light communications (ship beacon codes, modulated laser report and demonstration, and fiber optics report and demonstration). Reports will include description of sensors (antennae and detectors used in each technology).

Activity for Objective 9:

A. Have Indiana Bell engineer or other professional speak to class on telephone communications with question and answer period.

UNIT III: MICROSCOPE INVESTIGATIONS

Unit Objectives by Stage of Technology:

1. Students will look for things in their lives to investigate under the microscope. (L,M,H)
2. Students will prepare objects for viewing under a light microscope. (L,M,H)
3. Students will explain several uses of the videomicroscope. (H)
4. Students will explain how to properly use and care for a light microscope. (L,M,H)
5. Students will be able to label the parts of a light microscope. (L,M,H)
6. Students will practice labeling parts and functions of the microscope. (L,M,H)
7. Students will be able to properly handle the light microscope, prepare a wet mount and measure under the microscope. (L,M,H)
8. Student will be able to prepare pond water slides and record specimens using the videomicroscope. (H)
9. Students will prepare, record and view the video made from the videomicroscope. (H)

Activity for Objective 1.

1. Students bring in items to look at under the microscope.

Activity for Objective 2.

1. Demonstration by instructor of a wet mount and practice by students making wet mounts.

Activity for Objective 3.

1. Demonstration of the use of the videomicroscope. View video "The Invisible World".

Activity for Objective 4.

1. Demonstration on the use and care of the microscope.

Activity for Objectives 5&6&7.

1. The student will demonstrate ability to properly handle the light microscope, prepare a wet mount and measure with the microscope. Students will measure a letter "e" from the newspaper under the microscope. A wet mount is made of the "e".

Activity for Objectives 8&9.

1. The student will prepare pond water slides and record specimens using the videomicroscope. Using the prepared video, students will report on the specimens in their sample, pointing them out and explaining their part in the pond's ecosystem.

MODULE 3: SCIENCE

UNIT 4

SPECTROPHOTOMETRY

By

Denise Briner
Chemistry Teacher
Columbus North High School

Abstract

This unit provides sample lessons illustrating three levels of technological implementation of a unit on spectrophotometry.

Indiana Tech Prep Training Manual: Division II
Sponsored by
The Indiana Department of Education
Project # 92S-4762

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

SPECTROPHOTOMETRY

Introduction

The implementation of Tech Prep will occur under a variety of conditions at various locations. Some schools will have an entire team of teachers working together to implement a completely integrated program. Others will have only a few teachers working to integrate only two or three subject areas. Others still will have individual teachers teaching isolated courses. In the same regard, some schools will have a great deal of money to spend on technological hardware and others will not. Each of these situations will necessarily have different strategies for successful implementation.

With these various conditions in mind, the material covered in this sample lesson unit is targeted at three different stages of integration and three different stages of technological application.

Stages of Integration:

Stage I - Independent Tech Prep Teacher
Stage II - Pairs of Tech Prep Teachers
Stage III - Teams of Tech Prep Teachers

Stages of Technology:

Stage I - Low Cost Technology
Stage II - Moderate Technology
Stage III - Advanced Technology

Sample Lesson Unit for Tech Prep Chemistry.

Please refer to the last pages to see an outline of the entire course curriculum and a scheduled outline of the instrumentation unit.

Integration Level 1: The Independent Tech Prep Chemistry Teacher

Background Information on the Chemical Concepts.

Spectrophotometry is a technique used by chemists to measure quantities of substances in solution. For instance, hospitals use spectrophotometers to measure the quantities of sodium, sugar, and other substances dissolved in the blood serum.

Review Concepts.

Solutions. Solutions are homogeneous mixtures of a solute and a solvent. The solute is the material being dissolved in the solvent. For example, brine consists of salt as a solute dissolved in a solvent of water. Solids dissolved in liquids are the most common types of solutions but there can be other combinations. For example, carbon dioxide gas (CO_2) can be dissolved in water to make a solution of seltzer water. Air is a solution of several gases and metal alloys such as bronze and brass are solutions of solids.

Solution Concentration. When solutions are made the quantity of solute used is measured in grams but expressed in moles. The quantity of solution made is usually measured in liters. The combination of these two measurements is called molarity (M).

$$\text{Molarity} = \frac{\text{moles solute}}{\text{liters solution}}$$

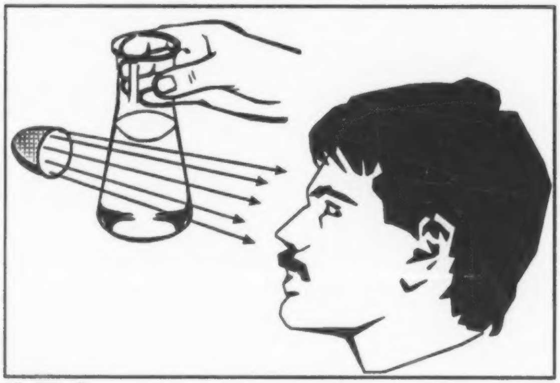
or

$$M = \text{mol/L}$$

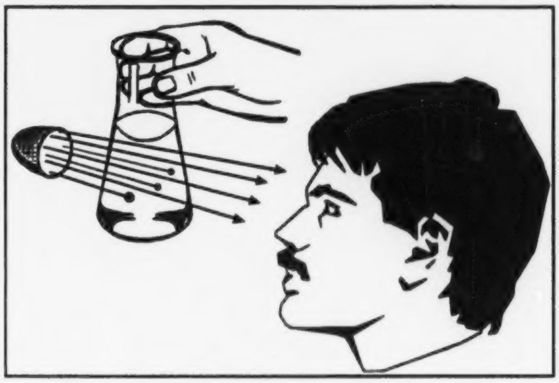
The more solute dissolved per liter of solution, the greater the molarity.

Measuring Solution Concentration.

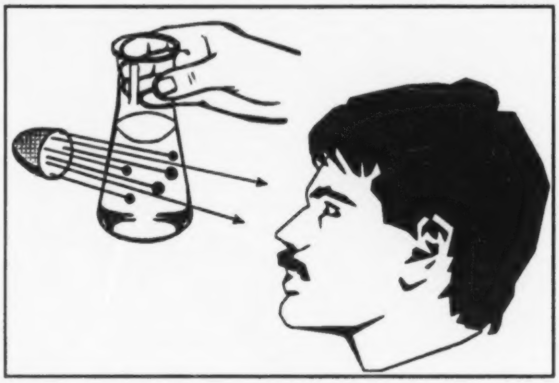
Spectrophotometry can be used to measure the quantity of solute dissolved in a solution. Spectro-photo-metry implies measuring with the spectrum of light. The basic concept behind spectrophotometry can be explained by the following schematic diagrams.



Shining a flashlight through solution samples and observing the amount of transmitted light is a spectrophotometer of sorts. A pure solvent, such as water, has no solute particles in it to stop the light. 100% of the light should be transmitted through the solution.



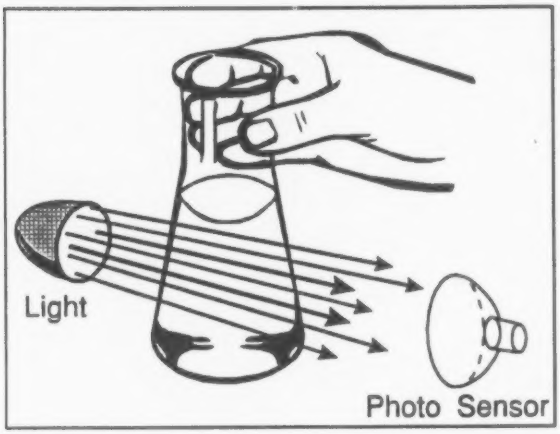
Solutions with some solute particles dissolved in them will cause some of the light to be absorbed. Most of the light is transmitted through the solution, but not 100% of it.



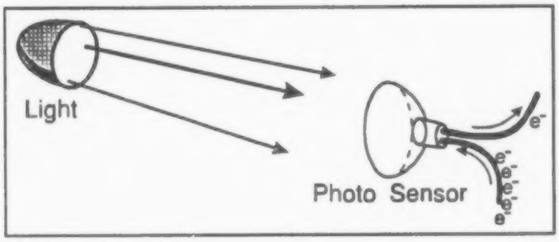
A solvent with a high molarity would have a great deal more solute dissolved in it. When light is passed through the sample more of it will be absorbed.

The human eye is very sensitive to varying intensities of light. However, it is difficult to report that quantitatively.

INTEGRATION LEVEL 2: INTEGRATION WITH AN ELECTRONICS TEACHER

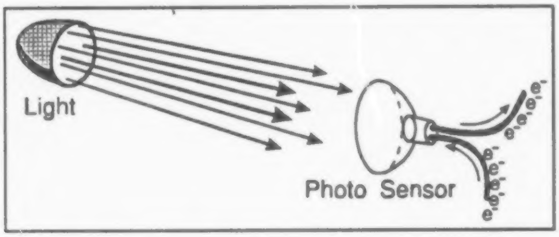


Simple electronic circuits can be designed that quantitatively monitor light intensity.



The electrical resistance of the photosensor increases with the increasing molarity of the solutions being tested.

Low light intensity = High resistance to electron flow.



High light intensity = Low resistance to electron flow

The changes in conductivity can be measured, recorded, and graphed in order to make a standardization curve.

INTEGRATION LEVEL 3: A TEAM OF TECH PREP TEACHERS (MATH & ENGLISH)

Math. The integration of a math lesson into this unit would consist of a session on graphing. Ideally this would include instruction on:

1. Labeling the axes.
2. Making appropriate scales for the data involved.
3. Plotting the graph.
4. Interpreting the graph.
5. Using the graph for unknown solutions through interpolation and extrapolation.

English. Integration of English into this unit could include lessons on technical report writing or the presentation of a demonstration speech on "How to build a Spectrophotometer".

IMPLEMENTATION LEVEL 1: LOW COST TECHNOLOGY

Constructing an Inexpensive Spectrophotometer. Adapted from the Woodrow Wilson/Dreyfus 1989 Chemistry Module

Purpose:

1. To assemble a cadmium sulfide (CdS) spectrophotometer.
2. To measure the concentration of colored solutions.
3. To determine the concentration of an unknown solution.

Description:

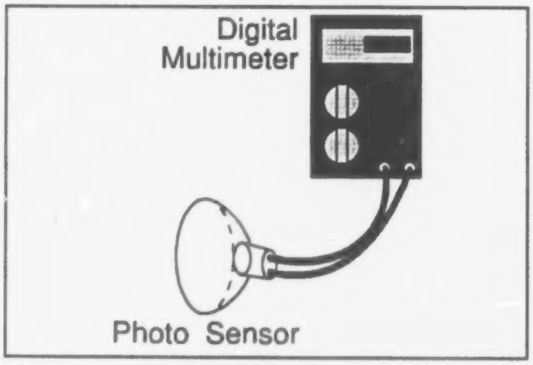
The CdS spectrophotometer consists of a CdS photocell, a multimeter, and two electrical leads. All parts of the spectrophotometer are simple and inexpensive. Yet, experimental results are reproducible and of high quality.

Materials:

1. red food coloring
2. prepared student unknowns from colored solution
3. multimeter (digital preferred)
4. CdS photocell (available from Radio Shack)
5. 2 electrical leads and/or hook up wire
6. Beral dropping pipettes or medicine droppers
7. distilled water

Procedure:

I. Assembling the Spectrophotometer:
   1. Attach the photocell leads to a multimeter. A digital multimeter (DMM) is recommended for reproducible results and higher resolution. (Inexpensive devices may be purchased from Radio Shack.)



2. Set the multimeter to the Ohms scale. Do not leave the multimeter in Ohms mode for long periods of time as the internal power source will be depleted.

II. Calibrating the Spectrophotometer

1. Fill five test tubes half full of distilled water.
2. Label each tube 1-5.
3. Add nothing to test tube #1.
   Add 1 drops of red food coloring to test tube #2
   Add 2 drops of red food coloring to test tube #3
   Add 3 drops of red food coloring to test tube #4
   Add 4 drops of red food coloring to test tube #5
4. Place the spectrophotometer directly under an overhead light source to assure reproducible light intensity without shadows. Do not move the assembly until all measurements are finished!
5. Using a Beral pipette, add distilled water to the face of the photocell to completely cover the cell in a single spherical drop.
6. Read and record the multimeter data.
7. Remove the drop by wiping the surface of the photosensor completely dry with a paper towel.
8. Repeat the drop procedure using the colored solutions, starting with the most dilute and finishing with the most concentrated, in sequence.
9. Plot a graph of resistance (in Ohms) against concentration (in drops). This serves as a calibration curve for the photocell/multimeter device.

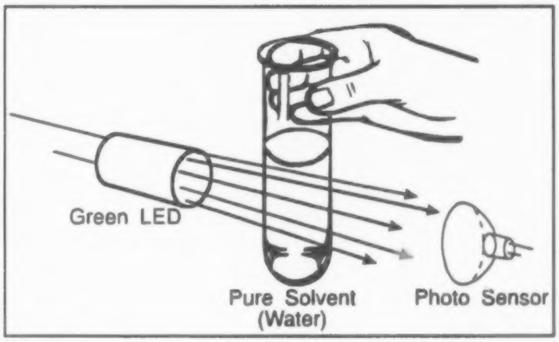
III. Determination of an Unknown

1. Obtain an unknown solution of the same stock name as your serial dilutions. Generate a resistance reading for the unknown using three trials and then average the results.
2. Determine the "concentration" of the unknown solution using your graph.

IMPLEMENTATION LEVEL 2: MODERATE TECHNOLOGY

Computer Interfacing a Homemade Spectrophotometer. Adapted from Radio Shack's Engineer's Mini-Notebook series, 1984.

The cadmium sulfide photocell can be turned into a monochromatic colorimeter that easily interfaces with a computer. Light from a green light-emitting diode (LED) passes through a small test tube before it strikes the CdS photocell. The resistance of the photocell, which varies with light intensity, can be monitored by the computer. The sensitivity of the CdS photocell is greatest in the green region of the spectrum, matching the color of the LED.

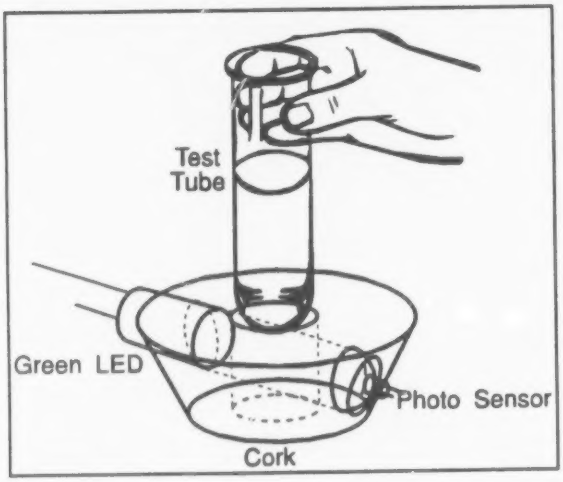


Parts List. Electronic Parts (from Radio Shack)

	Part	Cat. No.
1	CdS Photocell	276-116A
1	Green Subminiature LED	276-069
1	33-ohm, 1/2 - watt 10% Resistor	271-007
1	5-lug Terminal Strip	274-688
4-6 ft	24 GA SOLID 4-conductor Phone Cable	278-1320
1	500-ohm Potentiometer	271-226
1	Spool Rosin-Core Electronic Solder (0.032)	64-005
1	35 mm Film Canister	
1	Roll Black Electrician's tape	

Apple voltage reading program (Available free from project Seraphim - "Photon 2" or inexpensively from Vernier-"Voltage Plotter")

Part 1 - Cork Mounting Assembly.


Test Tube
Green LED
Photo Sensor
Cork

Drill a hole through the center of the cork using a cork bore just large enough so that your test tube fits snugly. Usually a 9/16" hole is about right. Perpendicular to this drill a hole just large enough for the LED. Directly opposite of the LED, drill another hole for the photocell.

Part 2 - Wiring the Photocell

1. Using a knife or wire strippers, remove 8-9" of the outer covering from one end of the length of the 4-conductor phone cable, exposing four colored wires.

2. Strip about 1/4" of insulation from the end of the yellow and green wires.

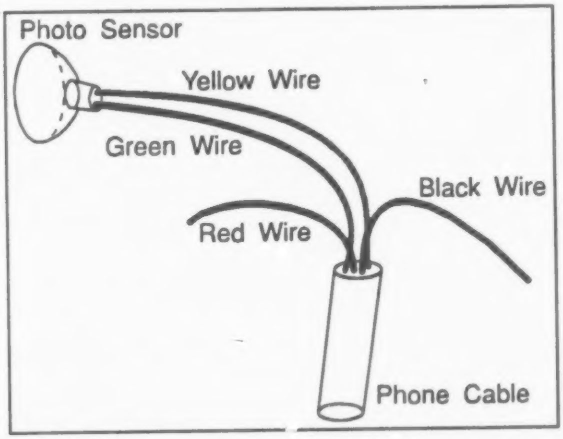


Photo Sensor
Yellow Wire
Green Wire
Black Wire
Red Wire
Phone Cable

3. Solder the yellow wire to one lead of the photocell and the green wire to the other lead.

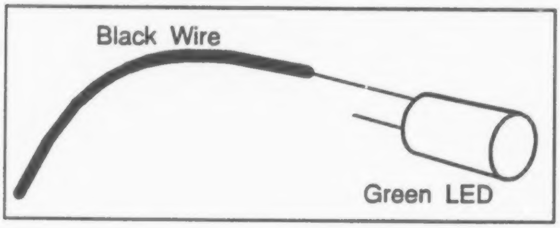
4. Seat the photocell in the cork. Cover the back of the photocell and the cork hole with black electrician's tape. Make sure that none of the exposed wires are crossed or touching and cover them with tape as well.

Part 3 - Wiring the LED

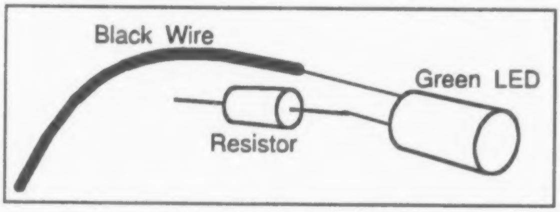
NOTE: The short and long leads determine polarity of the LED. It will not light and may burn out if they are connected incorrectly.)

1. Strip 1/4" of insulation from the black and red wires of the phone cable.

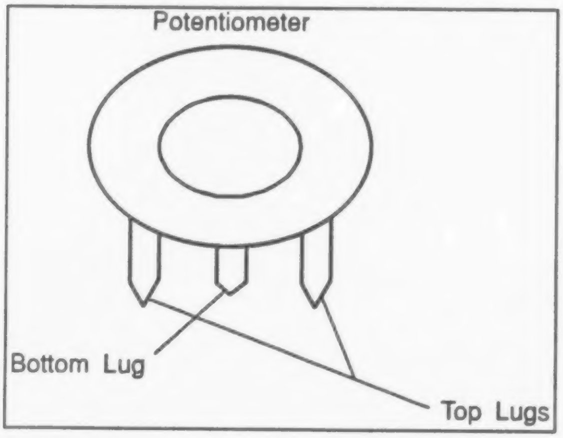
2. Solder the black wire to the long lead of the LED.


Black Wire
Green LED

3. Solder the short lead of the LED to the 1/2 watt, 33 ohm resistor.

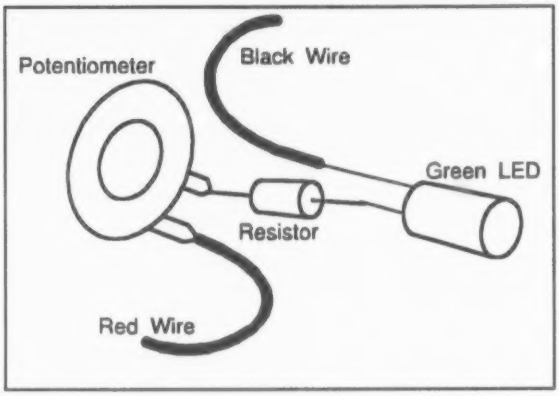

Black Wire
Green LED
Resistor

4. The potentiometer has 3 lugs protruding from it; two on the top (near the dial) and one on the bottom. Cut off one of the lugs on the top.


Potentiometer
Bottom Lug
Top Lugs

5. Solder the remaining lug at the top of the potentiometer to the red wire.

6. Solder the bottom lug to the other end of the resistor.


Potentiometer
Black Wire
Green LED
Resistor
Red Wire

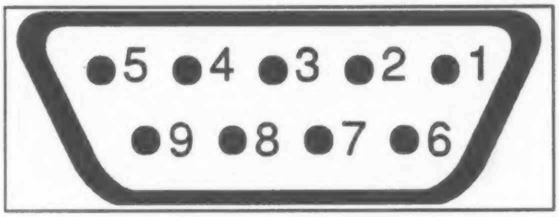
7. Seat the LED in the cork. Secure the potentiometer to the cork with tape. Cover the back of the LED and the cork hole with black electrician's tape. Make sure that none of the exposed wires are crossed or touching and cover them with tape as well.

Part 4 - Wiring the Apple Game Port Connector

1. Remove 8-9" of the outer covering from the opposite end of the 4-conductor phone cable, exposing four colored wires.

2. Strip about 1/4" of insulation from the end of all four colored wires.

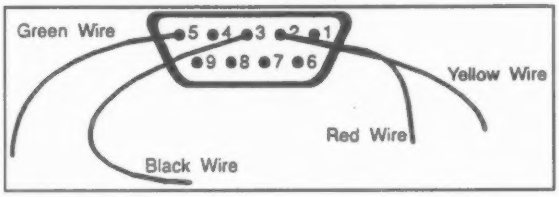
3. Look on the back side of the 9-pin game port adaptor. The pin numbers are marked as follows.



Find pin numbers:

PIN #2	+5 volt output
PIN #3	ground
PIN #5	paddle #0

4. Twist the red and yellow wires together. Solder both of these wires to pin #2. Solder black wire to pin # 3. Solder the green wire to pin #5.



5. Gently tug at each wire to check for good solder connections.

6. Bring your adapter to your teacher for a final check.

7. Make sure that any exposed wires are not crossed or touching. Coat the back of the adaptor with hot melt glue. This secures all wires in place and keeps the wires from crossing and shorting the circuit. Additionally, it provides a casing that makes plugging the adaptor in or out much easier.

Part 5 - Running the Experiment

1. Plug the game port adaptor into the apple computer. Turn the computer on and boot up the voltage reading program.

2. The first sample to run should be a distilled water blank. Fill a small test tube with distilled water. Wipe off any dirt or fingerprints with a paper towel. Seat the test tube inside the cork and cover with the black film canister. Follow the screen instructions to take measurements.

3. Replace the distilled water test tube with the first standard solution of food coloring saved from the previous experiment. Remember to wipe the outside of the tube with a paper towel. Cover the test tube with the film canister. Allow the computer to take measurements for a few seconds before continuing with the rest of the standard solutions and the student unknown.

4. Obtain a printout of voltage readings.

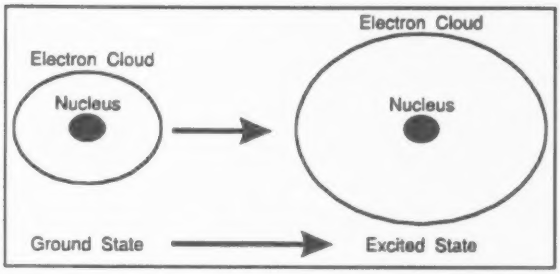
5. Plot the standard readings on a graph. Use this graph to determine the concentration of the unknown solution.

*** IMPORTANT: Save all solutions for use in the next experiment. ***

IMPLEMENTATION LEVEL 3: ADVANCED TECHNOLOGY

Introduction to the Spectrophotometer. Adapted from Laboratory Chemistry, Merrill Publishing Company, 1990.

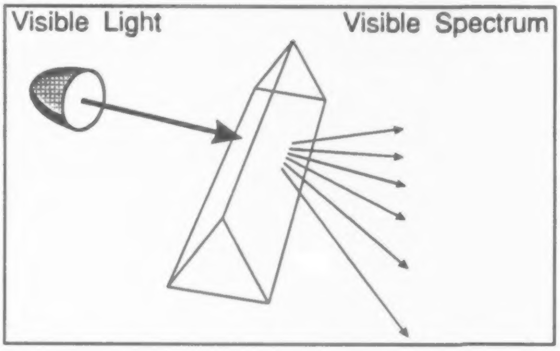
The **spectrophotometer** is a powerful tool used by scientists to obtain information about atoms, molecules, and ions. It is an instrument designed to measure the wavelengths absorbed or transmitted by a sample when exposed to electromagnetic radiation (light). The spectrum absorbed or transmitted is determined by the energy transitions which occur as the electrons in the sample move between their excited and ground states.



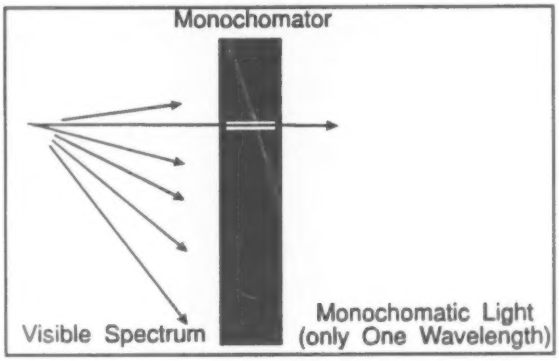
Every substance in solution has a characteristic set of wavelengths at which it absorbs visible light. In application, scientists can use the spectrophotometer to identify unknown substances and analyze the purity or the concentration of known substances.

The spectrophotometer contains a source of continuous radiation covering some portion of the electromagnetic spectrum, such as X-ray, ultraviolet, visible, infrared, or microwave. The continuous radiation is dispersed into a spectrum. In the case of visible light, the radiation is dispersed into the spectrum of visible colors.

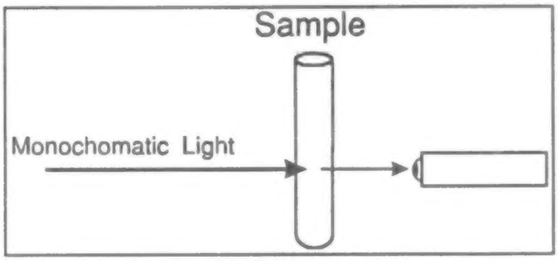
Example:



The spectrum passes through a monochromator which is adjusted to select a narrow band of wavelengths from the spectrum.


Monochomator
Visible Spectrum
Monochomatic Light
(only One Wavelength)

This band of wavelengths is directed through the sample to a detector. The detector measures the intensity of the beam absorbed or transmitted. A scale on the spectrophotometer records the detector's measurements as absorbance, A, or percent transmittance, %T.


Sample
Monochomatic Light

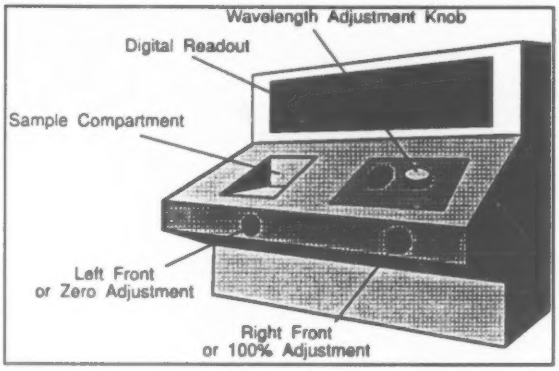
Objectives. In this experiment you will:

1. Learn how to operate a spectrophotometer;
2. Observe the effect of different wavelengths on the transmittance of light using samples of water and chalk;
3. Determine the maximum phototube response to water; and
4. Determine the concentration of an unknown solution.

Equipment. The spectrophotometer used for reference purposes in this experiment is a Bausch & Lomb Spectronic 20. The radiation band covered is the visible light spectrum and the radiation source is a tungsten lamp.

2 glass cuvettes
KimwipeTM (or other drying tissue)
Food coloring Solutions from the previous experiment
distilled water
white chalk

THE SPECTROPHOTOMETER


Wavelength Adjustment Knob
Digital Readout
Sample Compartment
Left Front or Zero Adjustment
Right Front or 100% Adjustment

Procedure.
Correlating Wavelengths to color of light:

1. Turn on the instrument with the left front (LF) knob and allow about 5 minutes for the instrument to warm up.
2. Set the digital read-out to % transmittance, %T.
3. Place a 3.0 cm piece of white chalk in a clean, dry cuvette. Wipe the outside with a Kimwipe$_{TM}$ or soft paper towel. The outside of the cuvette must always be kept dry and clean of fingerprints for accurate results.
4. Insert the cuvette into the sample compartment.
5. Set the wavelength adjustment at about 600 nm.
6. With the lid open, look down into the test tube and twist the tube until you can see light striking the chalk. The right front knob may need to be adjusted in order to see enough light.
7. Observe and record the color of light striking the chalk.
8. Adjust the top wavelength knob to 400 nm. Determine the color of light for every 25 nm from 400 to 600 nm.

Determining the maximum phototube response to distilled water:

1. With the sample compartment empty and the lid closed, adjust the LF knob so that the meter reads 0% T (transmittance).
2. Fill a clean, dry cuvette with distilled water. Wipe the outside with a Kimwipe or soft paper towel. The outside of the cuvette must always be kept dry and clean of fingerprints for accurate results.
3. Turn the right front (RF) knob fully counter clockwise. Insert the cuvette into the sample compartment.
4. Turn the wavelength knob on top through a wide range of wavelengths and observe how the meter reading varies with wavelength. Find and record the wavelength of highest transmittance.
5. With the wavelength set for maximum transmittance, adjust the RF knob to 100% transmittance.

Determining the concentration of an unknown solution:

1. Replace the distilled water test tube with the first standard solution of food coloring saved from the previous experiment. Remember to wipe the outside of the tube with a paper towel. Close the sample compartment lid and record the % T.
2. Remove the first sample tube and close the sample compartment lid. Readjust the LF knob to zero.
3. Place the distilled water test tube in the sample compartment after the outside has been wiped with a Kimwipe or paper towel. Readjust the RF knob to 100% T.
4. Replace the distilled water test tube with the second standard solution of food coloring saved from the previous experiment. Remember to wipe the outside of the tube with a paper towel. Close the sample compartment lid and record the % T.
5. Repeat steps 7 through 9 for each standard solution and the unknown. It is important to readjust the RF and LF knobs between each measurement.
6. Plot a graph of the standard solutions vs %T. Use this calibration curve to determine the concentration of the unknown solution.

RECOMMENDED LEVEL 4: ADVANCED TECHNOLOGY

All new Bausch and Lomb spectrophotometers have computer interfacing capabilities. All that is required is an inexpensive cable and some sort of voltage reading program.

RECOMMENDED APPLICATIONS: APPLIED TECHNOLOGY

Any of the three spectrophotometers can be applied to the measurement of a variety of solutions. The author uses the following spectrophotometric analyses: solution concentration, reaction rates, blood alcohol content, and plant chlorophyll concentrations.

Chemistry Technology

Course Outline

1. Forensics
2. Matter, Change & Energy
3. Atomic Structure
4. Electrons in Atoms
5. Chemical Nomenclature
6. Chemical Reactions
7. Chemical Periodicity
8. Scientific Measurement
9. Problem Solving
10. Chemical Quantities
11. Stoichiometry
12. ***Instrumentation***
13. Water/Water Solutions
14. Acids, Bases and Salts
15. Oxidation Reduction

Unit Outline/Schedule

TECH-PREP CHEMISTRY

Understanding Chemical Instrumentation

Tasks: When you've finished this unit you will be able to:

1. define the term instrument.
2. list the advantages to building your own scientific instruments.
3. define the terms current, voltage, resistance, and conductor.
4. describe the flow of current through a simple electronic circuit and construct a simple conductivity apparatus to measure this flow.
5. describe how a digital multimeter operates and use one in the laboratory to measure conductivity.
6. build and calibrate a silicon temperature sensor system.
7. construct a computer interfaced spectrophotometer and measure the change in light transmittance during a chemical reaction.
8. construct a computer interfaced gas chromatograph and measure chlorinated or fluorinated hydrocarbons.

BEFORE CLASS DO &/or STUDY	DAY DATE	CLASSROOM ACTIVITY	TOPIC(S) COVERED
Study Handout	Day 1	Discussion Prelab Quiz	Instrumentation & Electronic Circuits
Read laboratory handouts	Day 2	Lab Activity Handout	Constructing a simple Conductivity Device
Read laboratory handouts	Day 3	Lab Activity Handout	Using a Digital Multimeter
Read laboratory handouts	Day 4	Lab Activity Handout	Building & Calibrating A Temperature Probe
Read laboratory handouts	Day 5	Lab Activity Handout	Experimenting with your Temperature Probe
Study Handout & Lab Handout	Day 6	Lab Activity Handout	Computer Interfacing a Temperature Probe
Read laboratory handouts	Day 7	Lab Activity Handout	Constructing a Conductivity apparatus
Read laboratory handouts	Day 8	Lab Activity Handout	Experimenting with a Conductivity apparatus
Read laboratory handouts	Day 9	Lab Activity Handout	Constructing a Gas Chromatograph

Read laboratory handouts	Day 10	Lab Activity	Measuring CCF with a Gas Chromatograph
Read laboratory handouts	Day 11	Lab Activity	Computer Interfacing a Gas Chromatograph
Read laboratory handouts	Day 12	Lab Activity Handout	Constructing a Spectrophotometer
Read laboratory handouts	Day 13	Lab Activity	Measuring Concentrations With a Spectrophotometer
Read laboratory handouts	Day 14	Lab Activity	Computer Interfacing a Spectrophotometer
Read laboratory handouts	Day 15	Lab Activity	Using a Bausch & Lomb Spectrophotometer
Read laboratory handouts	Day 16	Lab Activity	Computer Interfacing a Bausch & Lomb Spectrophotometer
Review all Sections listed	Day 17	Written Exam & Lab Practical	Chemical Instrumentation

MODULE 4: TECHNOLOGY

INTRODUCTORY COMMENTS FOR TEACHERS

By

Duane D. Dunlap
Assistant Professor of Industrial Technology
Purdue University

Larry Helphinstine
Technology Teacher
Greenwood High School

Jeff Henderson
Technology Teacher
Columbus East High School

Neil Owen
Research Assistant
Department of Industrial Technology
Purdue University

Abstract

These introductory comments discuss the importance of competency based instruction and provide guidelines for developing competency based curricula for technology. Tech Prep instructional strategies are discussed in the context of technology, and the design process, a problem solving strategy of particular value in business and technical applications is presented.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Indiana Department of Education
Project # 92S-4762

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

Table of Contents

Introductory Comments for Teachers

The technology teacher in Tech Prep . . . 1
Competency-based instruction (CBI) . . . 2
    Why CBI . . . 2
    Are your courses competency based . . . 2
    Overview of competency based instruction . . . 3
    How to write CBI units . . . 6
    Scope statement worksheet . . . 7
    Tips for teachers when writing "Duties" . . . 8
    Tips for teachers when writing "Tasks" . . . 9
Tech Prep Instructional Strategies . . . 10
    Cooperative learning . . . 10
    Learning styles . . . 11
    Learning theories . . . 11
    Decision making . . . 12
    Problem solving . . . 13
    Project activity 1: Environmental concerns . . . 14
    Project activity 2: Video Yearbook . . . 16
Overview of the Problem Solving Process . . . 18
    Situation acceptance . . . 19
    Analysis . . . 19
    Brainstorming . . . 19
    Morphological forced connections . . . 19
Classroom Application of the Problem Solving Process . . . 21
Evaluating students on the Problem Solving Process . . . 22
Glossary . . . 23
References . . . 24

Unit 1: Experiences in Technology

Scope statement . . . 3
Phase 1 . . . 3
Phase 2: Task 1: Identify major internal components of an IBM computer . . . 4
Phase 2: Task 2: Use the format command . . . 5
Phase 2: Task 3: Use the copy command . . . 5
Phase 2: Task 4: Perform hard drive management operations . . . 6
Phase 2: Task 5: Manipulate data input devices . . . 7
Phase 2: Task 6: Use desk accessory applications . . . 7
Phase 2: Task 7: Perform diskette management operations . . . 8
Technology preparation proficiencies . . . 9

Unit 2: Integrated Material Handling

Introduction 3
Suggested competencies 3
Integrated activities matrix 4
Material handling unit 5
Overview of conveyer belts 6
Overview of Just-in-Time 7
Design brief: Automated manufacturing material handling processes 8
Lesson plan: Day 1 9
Lesson plan: Day 2 9
Lesson plan: Day 3 10
Log sheet 11
Lesson plan: Day 4 12
Suggested table for time and motion study 12
Lesson plan: Day 5 13
Suggested table for time and motion study 13
Homework 14
Glossary 15
References 16

Unit 3: Environmental Design

Introduction 3
Tech Prep drafting/CAD and the design process 3
Overview of water purification 3
Table 1: Water Treatment System vs. Common Contaminants 5
Integration activities matrix 7
Possible topics for discussion 7
Design brief 9
Lesson plan: Day 1 9
Possible ideation topics 10
Lesson plan: Day 2 11
Lesson plan: Day 3 11
Lesson plan: Day 4 12
Lesson plan: Day 5 12
Lesson plan: Day 6 13
References 14

INTRODUCTORY COMMENTS FOR TEACHERS

The Technology Teacher In Tech Prep

Preservice teachers and secondary education technology teachers involved in Tech Prep should provide courses in technology that integrate current, advanced, and future technology with other academic areas of the Tech Prep curriculum. These areas include mathematics, science, and English/communications in grades 10, 11, and 12. Viable technology programs should provide a conceptual approach to the systems of technology that is distinctive, and they should address the needs of the school population and geographic area being served.

Technology has many definitions. Many people define technology with words like progress, tools, machines, industry, computers, and change. Although these terms might describe some aspects of technology, they are not useful definitions. For the purposes of the Technology Module within Tech Prep, technology is defined as the creative application of mathematics, science, and English/communication to solve problems, meet people's demands, and extend human potential. The technology teacher in Tech Prep must have documented competencies that enable articulation among the other academic areas within Tech Prep and with postsecondary programs. Suggested high school courses with a systems approach could include: experiences in technology systems, computer-aided design or CAD/CAM, automated manufacturing processes, communication, systems introduction to engineering or principles of technology. These courses would be appropriate for Indiana high school students. Final course content is dictated by what provides technological literacy, what prepares students for postsecondary education and careers, and by other student needs.

The objective of the technology teacher is to cooperatively structure classroom and laboratory activities with mathematics, science, and English/communication teachers so that activities are truly interdisciplinary. The Indiana Model for Tech Prep provides the framework for implementation. However, specific regional curriculum development should be enhanced by the efforts of parents, business, industry, secondary, and post-secondary institutions. Teachers in your school will be looking to you for answers in the use and application of technology within their own curriculum. The technology teacher should respond by finding out what takes place in the other academic areas of Tech Prep. It is the responsibility of the technology teacher to enhance, modify, and develop activities that work toward the articulation and application of mathematics, science, and English/communications into daily technology lessons and activities.

The development and implementation of Tech Prep curricula can enhance learning at the secondary level by;

(1) increasing the number of Indiana high school graduates who are technically literate when they enter the workforce,

(2) increasing the number of Indiana high school graduates who can enter post-secondary institutions, or

(3) providing students with a practical and applied curriculum that emphasizes conceptual understanding of English, math, science, and technology.

Growing and successful organizations are locating geographically where they find a highly trained, productive, and literate work force. With the Tech Prep initiative in Indiana, they should find them here.

COMPETENCY-BASED INSTRUCTION (CBI)[1]

Why CBI?

- Curriculum based on competencies or proficiencies facilitates the development of articulation agreements between secondary and post-secondary institutions.
- Curriculum based on competencies or proficiencies will assist in the integration of academic and technical education.
- Competency based curriculum makes articulation with postsecondary programs easier.

Are Your Courses Competency-Based?

1. Do you hand each student, on the first day he or she is enrolled, a list of specific "tasks" or "competencies" that spells out exactly what they will be able to do as a result of your course and not just a list of topics or units to be covered?

2. Is your technology program based entirely on actual job skills (tasks) performed by competent workers in occupations and not on a textbook or course outline?

3. Have the tasks on which your program is based been verified (by others) during the last 12 months as being complete, accurate, up-to-date, and essential for employment?

4. Are you sure that the skills you teach in your program are the same skills that successful workers perform on the job today?

5. Can students skip instruction and receive full credit for any task in your program for which they can demonstrate mastery based on previous learning?

6. For each task students are to learn, are they provided with carefully designed, high-quality learning experiences and materials appropriate for both the student and the task?

---

[1] Materials throughout this section are based on Competency-Based Instruction (CBI). (Available from Indiana Association of Area Vocational Districts, Inc. (IAAVD), P.O. Box 24023, Speedway, IN 46224)

7. Are your student learning materials effectively organized or "packaged" in such a way that each individual student can begin a new task when ready and slow down, speed up, or repeat any part of the instruction as needed to learn?

8. Is each individual student helped and required to master each task at a high level of proficiency (95 to 100%) before being allowed or forced to move on to the next task?

9. Is each individual student required to perform each task to a high level of proficiency in a job like setting before being given credit for mastery?

10. Do you document to students and employers exactly what tasks each student has or has not mastered when each student leaves your program? (Adapted from Blank, 1982)

Overview of Competency-Based Instruction

Most businesses are demanding more and more from employees. Screening of future employees is also occurring to determine if they are capable of performing the tasks that their new jobs require.

As educators, we must ask how we can prepare students to succeed in today's and tomorrow's workforce. We must also ask how we can help students demonstrate their skills during interviews.

Competency Based Instruction (CBI) allows students to provide employers with proof of skills they have gained while in school. The concept is a simple one: the curriculum is written to express what the student can do as opposed to what the teacher can do or what topics are covered in the course.

Competency based instruction has four phases. **Phase one** is an outline of the major units of instruction with the subsections listed under each major unit of instruction. Also included in phase one is the scope statement which provides readers with a general overview of the course content, methodology, and purpose. The CBI format refers to these categories as duties and tasks. *Duties* are major areas of instruction, (much like a chapter title in a book) and *tasks* are the sub-sections or the "real meat" of a chapter.

Phase two includes duties and tasks, the performance guide, and the criterion reference measure. The *performance guide* is a list of what the student will do in each task, and the *criterion reference measure* states the method by which the student will be evaluated. When using CBI, the student must demonstrate competence in each task before he/she is allowed to move on to the next task.

Phase three is the *passport to employment*. The passport lists the duties and tasks in a list, and the student is given a competence rating on each of the tasks listed in the curriculum. Employers can look at the tasks and get a very clear idea of what students are capable of and the exact items of instruction that have been covered. Initials are often used to designate how well a student can perform each of the tasks; e.g. E (employable), P (productive), N (introduced), or T (not introduced).

Phase four is a test bank that can be placed on a computer so that each duty has a series of questions that cover all of the tasks contained within that duty. The *test bank* is used to create random tests for evaluation of how well the students retained the competencies covered in the duty. It is also a method of self evaluation for the instructor. There are several software packages similar to "MakeTEST" (for the Macintosh) that can be used to develop your test bank.

It is recommended that during the curriculum writing stage instructors enlist the help of business and industry personnel that are actively involved in a day-to-day application of the competencies to be taught. It is also recommended that the instructor use several different business or industry representatives so that the curriculum reflects the common needs of the business or industry community and does not become specific to one business or industry.

Traditional education programs have a great amount of diversity from classroom to classroom, school to school, and state to state. In the past, employers have had only course titles to go by in determining what topics have been covered. With the passport-to-employment, employers can look at the specific skills students have and the level of competence they have gained. Once business or industry personnel have assisted in the development of curriculum materials and have determined what competencies are important, they have little room to question what is taught in the local school.

The benefits of CBI are threefold: First, students benefit from acquiring up-to-date, marketable skills. Second, the business community benefits by having graduates with the skills necessary to succeed in the workplace. Third, schools and teachers benefit from the expertise of local business people.

The interaction among business and industry personnel helps eliminate "finger pointing" and encourages involvement in schools. The interaction between business and industry and schools should be a two-way street. Many employers would like to help develop their future workforce while students are involved in public instruction because this reduces on-the-job training costs. However, some attention should be placed on upgrading the skills of current employees so the employer realizes an immediate benefit from investing their time, efforts, and energy.

Competency based instruction requires the active involvement of business and industry for schools to be successful. This interaction can lead to business and industry partnerships that help all parties involved. A business and industry can often times help fund equipment and materials purchases, while schools can provide training areas and resources that the employers can use immediately. Internships for instructors and students are easier to arrange as a result of this cooperation. The internships for instructors provide up-to-date experiences in the day-to-day application of the activities being taught in the classroom. Internships for students provide reinforcement of classroom activities the students engage in, helping to answer the question so many students ask, "When will I ever use this stuff?".

Overview of CBI System

PHASE 1[2]

SCOPE: Overview of program

DUTY: Major activities performed in program

TASKS: Discrete tasks which make up each duty

CRITERION REFERENCE MEASURE: Performance profile

PHASE 2[2]

PERFORMANCE OBJECTIVES: Brief statement describing exactly what student must do to master task at entry level. Standard rule or text on which a specific judgement or decision can be based.

PERFORMANCE GUIDE: Steps taken to complete the performance objective.

PHASE 3[2]

INFORMATION LEARNING: Written tests

PERFORMANCE LEARNING: Performance tests

PHASE 4

TEST BANK: Development and Usage

---

[2] Adapted from Competency-Based Instruction

How to Write Competency-Based Instruction Units

1. List the major units of instruction in the program.
2. Assemble materials for use by teachers.
3. Prepare a scope statement for the course (one paragraph description).
4. Select and edit duties and tasks from resource materials.
5. Computerize a duty and task listing from the resource materials.
6. Write duty and task lists for units not included in resource materials.
7. Place duties in sequence in which they are taught.
8. Review the computerized duty and task list to make adjustments, additions, or corrections.
9. Duty and task lists are validated by employers (not on advisory committee).
10. Revise duty and task list.
11. Review and validation by advisory committee.
12. Revise duty and task list.
13. Provide input for designing a certificate of competencies.
14. Develop certificate of competencies (VISA/PASSPORT) to be awarded to each student upon successful completion of the program.
15. Identify or develop related academic skills and employability skills.
16. Develop performance objectives for each task.
17. Develop performance guide for each task.
18. Develop and validate pool of evaluation items.
19. Identify instructional activities and methodology.
20. Evaluate and revise curriculum materials annually.

Scope Statement Worksheet[3]

Instructor Name ____________________

Possible Components

- A. Brief statement of program goal
- B. Major areas of instruction
- C. Occupations graduates may enter
- D. Emphasis of laboratory experiences
- E. Length of program
- F. Grade level of students
- G. Prerequisites (if any)

Local Program Title (Answer A-G to develop Scope Statement):

---

[3] Taken from Competency-Based Instruction

Tips for Teachers When Writing "Duties"

1. If you were writing a book describing what the worker does in the occupation, the major chapter would probably be duties. The real meat of each chapter would be the specific tasks that the workers perform and are paid for.

2. Some occupations are made up of as many as 10 to 15 duties; others have only one or two; and some specialized occupations (such as typist) are really a single duty within a broader occupation (secretary).

3. You may want to begin duty statements with the "ing" form of an action verb to show the ongoing nature of the duty and to help separate duty and task statements (more about task statements later).

4. Some occupations will include duties involving activities such as supervising, training, and organizing, as well as the more common duties involving "hands on" tasks.

5. To identify duties, think about what different kinds of activities the worker actually performs on the job during the first year or two.

6. On any one day, a worker may be involved in performing specific tasks in several duty areas.

7. A good place to look for duties is in a job description that is written about the occupations you are preparing students for.

8. If the duty areas seem to build on each other, list them in the order that a typical student might go through them in a training program. If the duties can each stand alone and the tasks in one duty need not be learned before beginning the tasks in another, list them in alphabetical (or other) order.

9. Such topics as "using equipment," "maintaining a safe environment," "mastering principles of electronics," and " maintaining professional ethics" are not duties. None of these examples describe categories of tasks for which the worker would be paid. Use of equipment, following safety, electronics principles, and ethics are all areas of knowledge and attitudes which are worthless to consumers or employers by themselves. Using knowledge and attitudes to perform competently is what earns a paycheck. (Adapted from Blank, 1982)

Tips for Teachers When Writing "Tasks"

A Job Task...

1. Is a valuable accomplishment for which an employer or consumer is willing to pay.
2. Is a complete unit of work performed on the job; when completed, the worker feels that something has been accomplished.
3. Has definite beginning and ending points.
4. May be broken down into several procedural steps, from start to finish.
5. May be a typical assignment given to a worker on the job.
6. Results in a finished product or service or change in the work environment.
7. Has meaning for trainee to want to learn; results in some meaningful accomplishment.
8. Makes sense for the student to learn as a separate instructional unit.
9. Begins with an action verb in the present tense.
10. Is short and precise.
11. Can usually be learned in about 6 to 30 hours.

Additional "Task" Tips...

1. Each statement should stand alone.
2. Avoid using "be able to" or "the student will" or other such beginning phrases; they just waste time and space.
3. A worker in the occupation should be able to read the task and rate it as to the importance and how often it is performed.
4. Use the acceptable terminology used in the occupation.
5. Try to avoid using double verbs, such as "remove and replace." Use the more inclusive of the two (repair means to remove and replace).
6. Do not include any phrases that have to do with the knowledge needed to perform the task; focus on the skill.
7. Do not include any mention of performing a skill safely. Safety will be learned right along with each step required to perform the skill.
8. Avoid flowery terms such as "correctly," "accurately," and so on. We assume that the student will be taught how to perform the task correctly. (Adapted from Blank, 1982)

The principles described in this section are illustrated in Unit 1: Experiences in Technology which follows.

Tech Prep Instructional Strategies

One of the first questions which must be addressed when creating a curriculum is how one goes about developing a curriculum. By far the most influential set of ideas about how to make a curriculum is embodied in the "Tyler rationale." In fact, Daniel Tanner and Laurel Tanner (1980) claim that the Tyler rationale is the paradigm--the dominant model of twentieth-century thought--about curriculum design.

Tyler organizes his rationale around four fundamental questions which he claims must be answered in developing any curriculum:

1. What educational purposes should the school seek to attain?
2. What educational experiences can be provided that are likely to attain these purposes?
3. How can these educational experiences be effectively organized?
4. How can we determine whether these purposes are being attained?

Evaluation. In other words, Tyler is making it clear that when constructing a curriculum you need to first think about your aims and objectives (question 1) and second about the kind of subject matter or experiences that will most likely help students achieve those objectives (question 2). These then need to be put together programmatically (question 3), and, finally, the results of using your curriculum need to be evaluated in some way (question 4) (Walker & Soltis, 1986, pp. 45-46).

Cooperative Learning. Cooperative learning is discussed in Chapter 4 of Division I. This discussion focuses on the application of cooperative learning in technology classrooms. Mergendoller & Marchman (1987) state:

> [There are] two commonly used cooperative learning approaches. In the first, students work together to study the same lesson without taking responsibility for learning and teaching others specific parts of the lesson. In the second, a complex lesson is broken down into smaller parts, and each student takes responsibility for mastering and teaching the rest of the group about a specific part. In both cases, the way in which the teacher evaluates students' work and assigns rewards influences how much students learn.
>
> When students work together to learn the same material and are not given different parts to master, student achievement increases only when the group is rewarded when all members of the group succeed in learning the material. Making the group's award contingent on individual performance spurs on all members of the group. Approaches that only encourage students working on the same task to "use each other as resources" and then reward the group irrespective of individual accomplishments are no more effective in producing academic achievement than those requiring students to work completely on their own. By contrast, when individual students are assigned different parts of a larger task, achievement is encouraged when group rewards are based on the group's overall success rather than the individual successes of its members.

> If rewards are given according to individual contributions, this will not encourage all group members to contribute (p. 310).

When first using cooperative learning in a classroom situation, a teacher should start slowly. The teacher should select a favorite class, preferably a small one, and the teacher should gradually add more classes as success is achieved. At the beginning, cooperative learning should be used with each class approximately one or two times a week.

It is imperative to remember the role of the teacher is that of a facilitator. Furthermore, the teacher's role requires the teacher to guide students into learning teams, called base groups, where maximum achievement and improved social skills are goals. All base groups should have diversity. Students' intelligence, sex, race, and age are areas of diversity to be considered.

The teacher first assigns roles to each student. For example, a technology teacher could assign students the roles of job supervisor, timekeeper, recorder, equipment supervisor, and union steward. Then, cooperative learning starts with the base group instruction where the goal is to unite into a team.

Cooperative learning requires that the students be able to accomplish processing tasks. For example, the students need to be able to answer the following questions: "What did we do well? How did we do it?, and What could we do better next time?" It is important that the teacher not allow a mere review assessment of the lesson.

Learning styles[4]. Yet another consideration for the teacher is the students' learning styles. Learning styles are nothing more than formal attempts to capture what goes on in effective communication. Learning style ideas attempt to make part of the teaching-learning and counseling transactions explicit (Hunt, 1982).

Researchers have considered learning styles from four dimensions: cognitive, affective, psychological, and physiological. The cognitive dimension of learning style refers to the different ways that students mentally perceive and order information and ideas. The affective dimension refers to how students' personality traits, both social and emotional, affect their learning. The psychological dimension involves the student's inner strengths and individuality. How does the student feel about himself? The physiological dimension involves the senses and the environment. Does the student learn better through auditory, visual, or kinesthetic/ tactile means? And how is he affected by such factors as light, temperature, and room design? (Butler, 1988).

Learning theories. Psychological learning theories have four schools of thought: psychoanalyst, behaviorist, cognitive, and humanist. Of these four schools, the behaviorist and humanist schools have had the most impact on education during the last half of the twentieth century.

---

[4] This topic is discussed more extensively in Chapter 4 of Division I.

Behaviorists, like Skinner, suggested that "learning occurs when learners acquire associations, or bonds, between a stimulus and a response and change their behavior accordingly." Much of today's computer programs are based on Skinner's programmed instruction theory (Bellon, Bellon, & Blank, 1992, p. 396).

Early in the 1970's, the principal psychological learning theory changed from the behaviorist to the cognitive school. "Cognitive scientists share Piaget's constructivist view of learning, asserting that people are not recorders of information but builders of knowledge structures" (Bellon, Bellon, & Blank, 1992).

Brophy's (1987) cognitive view of learning was that learning referred to information processing, sense making, and comprehension or mastery advances that occurred during the acquisition of knowledge or skill. In his view of learning, performance referred to the demonstration of such knowledge or skill after it had been acquired (p. 41)."

Snow (1989), noted learning involves a progression from simpler to more complex comprehension of a domain. As students acquire a more sophisticated information base and more complex concepts, they must restructure and replace their old beliefs. Deep understanding often involves unlearning as much as learning. Resnick and Klopfer (1989) stated that students know something only when they receive information, interpret it, and relate it to other knowledge. Thinking and learning merge in the cognitive perspective and should not be separated.

Another well-known learning theory developed by Morrison is mastery learning. "In developing the concept of mastery learning, Morrison distinguished between learning and performance. First, the student focuses on learning a skill and acquiring a fundamental grasp of subject matter; this is what Morrison calls *mastery*. Once the student has achieved a certain level of learning, he or she attempts to apply the skill; this application of learning after mastery is called *performance*. The next step after performance is achieved is *adaptation*, the stage at which students become able to apply their learning in any situation. Adaptation is unitary and permanent: one either masters a skill or does not, and once a skill is mastered it does not fade away" (Miller & Seller, 1985, pp. 40-41).

A performance objective is a statement describing desired student performance, the conditions under which the performance is to occur, and the criteria by which the performance will be evaluated. The student is expected to be able to do something, rather than to simply know something. Thus, while knowledge is required in order to perform correctly, emphasis is placed on observable behavior.

Decision-Making. Decision-making may influence the identification of appropriate solutions to the problem. One aspect of the decision-making process deals with the various strategies used to expedite that process. "Educators have several unique and well-accepted strategies from which to choose as they approach the business of decision-making. Although each of the various strategies is useful in its own right, the creative decision maker should strive to develop and perfect a composite strategy that might include several of the following: *management by objectives* (MBO); *decision matrix*; *program evaluation and review technique* (PERT); and *advocate team process*.

Problem solving. Another approach to decision making consists of what many refer to as problem solving. In reality, regardless of which decision-making approach may be used by an organization, all involve problem solving. The approach commonly used when employing problem solving consists of:

1. Identifying that there is a problem (Situation Acceptance)
2. Analyzing the problem (Analysis)
3. Defining the problem and goals (Definition)
4. Arriving at appropriate alternative solutions (Ideation)
5. Selecting the best alternative solution to the problem (Selection)
6. Implementing the solution (Implementation)
7. Evaluating the success of the solution and repeating the process (Evaluation)

This process is described in a much more detailed fashion in Chapter 4 or Division I and in the following chapter entitled "The Problem Solving Process." Many times the most difficult aspect of the problem solving process is not jumping directly to the forth step (Ideation). The purpose of the first three steps is to positively identify the problem, find out what is causing it, and define what you want to do about it. If these steps are neglected, you may find that a symptom has been cured while the disease rages on. Once the definition stage has been completed, the process is well under way. Once the problem has been clearly stated:

> Helping students engage in higher level learning (critical thinking) is a challenging task. What students bring to higher level learning experiences, in the form of prior knowledge, is a major influence on the success of the learning experience. By using a variety of cognitive organizers, teachers can facilitate student learning of complex information. Students can learn to monitor their own thinking processes, which in turn will assist them in becoming self-regulated learners. Teachers can design instruction to focus on and strengthen concept formation so that students can organize information in a meaningful manner. It is difficult, however, for teachers to change previously learned misconceptions. Teachers can teach higher level thinking skills through direct instruction. They can reinforce the thinking skills they want students to acquire by modeling higher level thinking as they engage in the instructional process (Bellon, Bellon, & Blank, 1992, pp. 25-26).

The following projects provide concrete examples of instructional activities that incorporate the Tyler rationale, applications based instruction, cooperative learning, learning theories, learning styles, decision-making, problem-solving, and critical thinking. The first project is a semester long program, and the second project is planned for a year. The semester long activity uses an approach where the product is made, with plans for marketing and selling to follow. The year long activity uses an order procedure followed by production of the product, a video yearbook.

Project Activity #1: Environmental Concerns

Problem: Produce and market a profitable product which would contribute to the improvement of the community's environment.

Experience

1. Form teams or groups to survey the people about the community's environmental needs.
2. Research and investigate environmental problems facing our world today and previous attempts to improve the environment.

Organization

3. Discuss and analyze information obtained from committees and research.
4. Select an environmental problem of the community that could be improved using critical thinking. Decide feasibility, practicality, recycling problems, etc.
5. Brainstorm ideas of products that could improve the environmental problem your group has selected. (Decision-making)
6. Select a product, e.g. a can crusher.
7. Construct one or two test models of the product.
8. Select the model that is the most functional and feasible to produce. Look at the cost of production, appearance, effectiveness, environmental benefits, and selling price. Also investigate the availability of raw or secondary materials and their costs.
9. Determine cost of production and profit margin. (Math and Business Applied Economics).
10. Test market the product.
11. Determine feasibility and profitability of marketing product based on test marketing results.
12. Redesign model or adjust pricing based on test marketing results.
13. Determine feasible marketing area.
14. Design and implement an advertising campaign for the product.
15. Market final product.

Final Evaluation

16. Liquidate the enterprise, calculate profit-lost margin at end of product sales. Analyze the impact the product had on the community's environment. Discuss ways the project might have been more successful. (Critical thinking)

Outcomes

1. Understanding of environmental problems
2. Improved relationship between school and community
3. Understanding of principles and laws of science
4. Application of mathematical calculations
5. Understanding of market influences and process
6. Develop and refine critical thinking skills
7. Utilize problem-solving methods

Time Line for Environmental Project

Time Period for the Project	English	Math	Science	Technology
First 6 Weeks	Write, conduct surveys	Tally the surveys, and know use of applied math	Provide background on environment and construct models	Construct more models
Second 6 Weeks	Ad Campaign	Setup accounts and assist in product	Quality Assurance	Produce Product
Third 6 Weeks	Post-survey distribute annual report Evaluate	Accounting P/L ledger Write checks	Evaluate effectiveness of product on the environment	Service products improve design for future

Project Activity #2 - Video Year Book

Problem: To produce and market a profitable product to the student body which would improve the climate of the school.

Experience
1. Survey students, faculty, administration, and parents to determine interests and needs.
2. Research elements of school climate.
3. Determine a need or interest to address which will improve school climate.
4. Discuss possible products which would address selected need.
5. Research feasibility and profitability of producing two or three selected products.
6. Determine product to produce (i.e. elements involved).
7. Research availability and cost of raw and secondary materials and production facilities.
8. Determine cost of production.

Organization
9. Produce sample product.
10. Survey students, faculty, administration, and parents to determine interest in purchasing the product.
11. Construct advertising campaign for the product based on results from #10.
12. Collect orders for product.
13. Determine production numbers based on orders.
14. Produce product.
15. Distribute product.

Evaluation
16. Calculate profit-loss margin. Discuss how product improved school climate. Evaluate how project might be improved.

The Video Yearbook

Design and construct a video yearbook depicting school-life throughout the year.

English:	provide background information on school climate, conduct surveys, develop advertising campaign, distribute videos and evaluate project.
Math:	tabulate survey results, set up and run business, liquidate business, and tabulate production numbers.
Science:	Research alternative types of video production editing, and assist Technology in producing the product.
Technology:	Produce a sample segment of a video yearbook for advertising purposes.

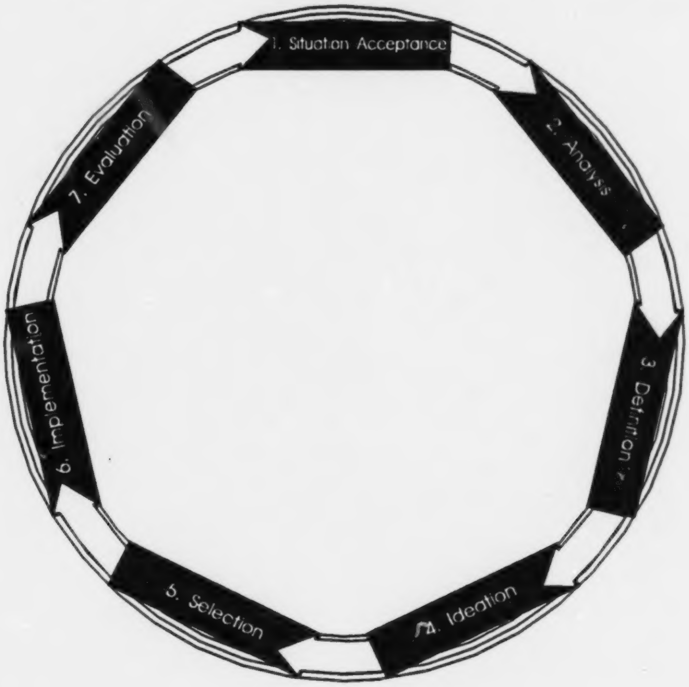
Time Line for Video Yearbook

Video Year Project	English	Math	Science	Technology
First Semester	Provide School Climate Background Survey Develop ADS Aid in production of prototype	Tabulate results of survey Cost-benefit of prototype finances supply/ demand projections	Research for alternate product Evaluate alternatives and make recommendations Aid in design of prototype	Produce sample product for advertising
Second Semester	Distri-bute product & conduct Post-Survey Evaluate project	Conduct business Liquidate business tabulate post-survey results	Aid in production of the product	Produce & service product

Overview of the Problem Solving Process[5]

The term, problem solving, has become a major buzzword in both education and industry. When company management is asked what abilities students should have upon graduation, problem solving is always on their list. Today's businesses compete internationally. To be an effective contender they must have an educated workforce that can think and respond independently of management. A workforce of creative problem solvers is vital if the United States is to regain its leadership role in international trade.

Creative problem solving, otherwise known as the design process, is simply a series of logical steps that is used to solve problems. The process can be used to discover a solution to many problems in virtually any area of concern: manufacturing, biology, the environment, product design, automotive styling, engineering, ergonomics, teaching, etc. The process is composed of seven basic steps (Koberg, 1981). These are: 1. Situation Acceptance, 2. Analysis, 3. Definition, 4. Ideation, 5. Selection, 6. Implementation, 7. Evaluation. These steps do not exist in isolation; rather, there is constant and continuous feedback. Each of these steps does not have a specific starting and stopping point. In fact, each step could go on indefinitely. The diagram below shows one representation of the problem solving process.



---

[5] Problem solving is discussed in Chapter 4 of Division I. This material focuses on the design process, a common mode of problem solving in technical fields.

Situation Acceptance. Situation acceptance involves recognizing that there is a problem, determining that improvements can be made, and deciding that the potential improvements have real value (e.g., money, time, ease-of-use, safety, etc.). The best way to approach the problem is to identify it as a challenge.

Analysis. The analysis stage incorporates traditional research. In this stage the "designer" is asked to discover the "world of the problem" (Koberg, 1981). This involves learning the way an object or system *should* work, how it *is* actually working, what *makes* it work, etc.

Definition. The third step, definition, distills information from the two previous steps into the primary issues. These issues are then used to create the goals that the designer will aspire to throughout the rest of the process.

Ideation. Ideation, the fourth step, is probably the most critical step in the process. Many people mistakenly begin their problem solving process with ideation. This is acceptable ONLY if the designer has created specific goals and is already fluent with the situation or product. Many of those who fail to begin with the first two steps end up wandering aimlessly between a series of irrelevant solutions to minute problems that really do not make a difference. The real purpose of ideation is to uncover ALL of the possible solutions to the stated problems. By stating the purpose this way, it implies that the ideation phase is never ending. Quick *orthographic*, *isometric*, *thumbnail*, or *perspective sketches* (see *Glossary* for definitions) are usually the preferred method of recording and displaying these ideas. There are several methods that can be used to help create new ideas. A couple of these, brainstorming and morphological forced connections are described in more detail on the next page.

Brainstorming. The method of ideation that most people are familiar with is "brainstorming." This method works best with small groups between 5 and 25 participants. It is also important to maintain an "energy level." Brainstorming sessions should not spend more than 5 minutes per topic and not last more than twenty minutes in their entirety. Follow-up sessions (usually the next day) can be a good way to collect additional ideas that developed after the session was over. Brainstorming incorporates four rules that facilitate creative solutions (Koberg, 1981). The first rule is to defer judgment. In other words, do not criticize any idea no matter how relevant it appears at first. The second rule is to allow "designers" to free-wheel. Do not force conversation in a specific direction. Let the students explore new, uncharted territory. The third rule suggests that adding to an existing idea is desirable. Entirely new ideas are not required; improvements on old concepts are fine. The final rule suggests that the quantity of ideas is desired over their quality. Many times the best ideas evolve out of what initially appear to be the worst solutions.

Morphological Forced Connections. The second method of ideation, morphological forced connections, is an under-used method of idea generation. This method is extremely useful in product design and probably the most enjoyable. The object to be designed (or refined) is broken down into its primary attributes (e.g., form, material, manufacturing process, color, etc.)(Koberg, 1981). These attributes will vary from project to project. The next step is to create a list under each attribute. Finally, after all of the lists are complete (between 5-40 items in each list), randomly select an item from each list and combine these to form a new invention. The method is demonstrated on the next page.

Sample Morphological Forced Connection.

Step 1: Define task
Redesign a shock absorber for a remote controlled 4 x 4.

Step 2: Define attributes (think of at least 4 categories)

Attributes:

Form	Material	Process	Color

Step 3: Ask the students for examples of "Forms", "Materials",etc. Try not to judge or inhibit students. Sometimes the more radical the answer the better the final solution.

Attributes:

	Form	Material	Process	Color
1.	Cylinder	Steel	Machining	Black
2.	Cube	Rubber	Molding	Red
3.	Conic	Pudding	Extrusion	Neon Green
4.	Belt	Carbon Fiber	Stamping	Navy Blue
5.	Spiral	ABS	Blow Molding	Turquoise
6.	Sphere	Silly Putty	Baking	Sunset Orange

Step 4: Randomly select elements out of each "Attribute" category. There were six elements in each category in the above sample, so a normal (6-sided) die was used.

The results of the die rolling were: 1(Cylinder)-6(Silly Putty)-3(Extrusion)-5(Turquoise).

Step 5: Take the selected elements and use them to "spark" an idea or concept.

A turquoise, cylindrical shock absorber made out of silly putty. Although at first this may seem ludicrous, it would offer most of the advantages of a hydraulic shock absorber and could be relatively inexpensive to produce.

Step 6: Repeat Step 4 (random selection) several times.

Selection. Selection, the fifth step in the problem solving model, compares the defined goals with the solutions that were created in the ideation stage (Koberg, 1981). At this point emphasis should be placed on what appears to be the most practical solution or solutions that best solve the stated problems. If time and materials permit, it is best to select two or three solutions rather than choosing one. Usually, the selections include a "radical" (totally unexpected) solution, a "traditional" (conventional) solution, and one that is in between. This allows the "designer" to experience a wider range of the "solution continuum" and in the end a better problem solver. This diversity approach also displays the designer's range to the "client" (teacher, industry professional, or company) and gives a better measure of their abilities.

Implementation. The sixth step in the problem solving process is implementation (Koberg, 1981). This stage takes the selected solution(s) and manufactures them. The finished products can range from sketch models to fully functional prototypes.

Sketch models are nothing more than three dimensional sketches. Materials include paper, cardboard, found objects, etc. Emphasis is placed on quick construction. The model should roughly represent the form of the object and simulate the movement and function. Functioning prototypes are for all proposes the final form of the product. The model offers full functionality, surface appearance, materials, and simulated manufacturing processes (e.g., vacuum forming for blow molding, etc.). In between sketch models and functioning prototypes are appearance models. These models look like functioning prototypes and sometimes have limited functionality, but that is about as far as the similarity goes. Appearance models can use any materials or processes to get a good representation of what the final product will look like. Many times these models are used for market research. A good example of this is many of the "concept" cars at auto shows. Most of the time they are simply painted, clay models.

Evaluation. The final step in the problem solving process is evaluation (Koberg, 1981). This is the point where the actual progress that was made is weighed against the goals that were stated in step three, definition. Not only does this step measure the relative success, it also should suggest revisions and refinements. Without this feedback loop it would not be the true problem solving process. Again, constant feedback implies a never ending process of constant improvement (Koberg, 1981). Technically, the process should ALWAYS go through at least two complete cycles before it is terminated. However, this is not always possible in the high school environment due to constraints on time and resources.

Classroom Application of the Problem Solving Process

Since most high school students are unfamiliar with the problem solving process, it will be necessary to lead them through the process the first few times. The following sample units (bar coding, water purifier, and material handling) will each incorporate the PSP to varying degrees. One of the most crucial aspects to the students will be daily feedback on their ideas and concepts. The best method for this is a regular critique. Have the students put all of their work on their desks or pin it up on a wall so all can see. Initially the instructor should do the critique, but as the students become accustomed to the method, they should be allowed to contribute their comments and suggestions. The following guidelines should be used during a critique:

1. Be honest when you critique. Nothing ruins credibility faster than lying.
2. Watch out for feelings. Positive feedback is important. Focus on what was done right. Try to find at least one good thing for every bad thing.
3. Devote an equal amount of time to each student. Try not to focus on only the good students. They need your help the least.
4. Make the critique fun, but not at the expense of any students.
5. Maintain a high energy level (enthusiasm).

As mentioned earlier, the problem solving process is never-ending. Therefore it is up to the teacher to control the time allotted to each step in the process. The ideation and implementation steps should comprise approximately 70% of the total project time. Also, it is extremely important to let the students experience the entire process, including revision, so allow time for the second cycle.

As students become comfortable with the design process, they should be encouraged to divorce themselves from their ideas. This serves two purposes. First, it allows the student to objectively evaluate their ideas; and secondly, it helps them to avoid misunderstanding a bad critique as a personal attack. As personal "ownership" of ideas decreases, students and groups of students will begin to function in a more symbiotic relationship. In other words, student cooperation will increase, and the problem solving ability of the class as a whole will accelerate.

Evaluating Students on the Problem Solving Process

Final grading of the problem solving process is difficult. There are no right or wrong solutions, rather there are only varying degrees of better or worse. The most prevalent method is an ordinal measure (ranking from better to worse). It is usually best to include the assistance of a colleague (preferably a non-technology teacher) in the final ranking and grading. This removes some of the inherent bias and offers a fresh perspective to the solutions.

A "project portfolio" offers an excellent overview of the problem solving process. It provides the Technology Teacher with the student's entire project and its development. The student will be able to use it as reference material for future projects and to show his proficiencies to future employers. The portfolio should document all stages of the problem solving process (e.g., wordlists, concept sketches, renderings, photographs of sketch models and prototypes, revisions, etc.). The Technology Teacher can ease the final task of assembly by making sure that all assignments are turned in on the same size of paper (8.5 x 11, A, C, D, etc.). The final project portfolio could be placed in a three-ring binder or simply stapled together.

GLOSSARY

conventional - an idea that fits with traditional concepts or methods.

critique - an accurate review of work or ideas that is communicated back to the "designer."

designer - a term used in this unit to describe the person solving a problem.

ergonomics - the study and application of human factors.

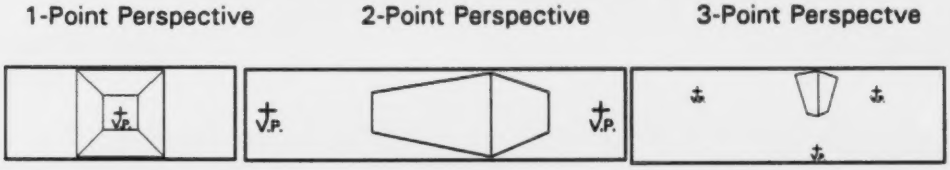
feedback - the return of information about the results of an act or process.

freehand - without the aid of a ruler or straightedge.

isometric - a simulated perspective without vanishing points. This style offers a relatively realistic image and scalable dimensions.

orthographic - description of an object by projecting the object on planes (e.g., top, front, right side, etc.)

perspective - a true representation of a three dimensional object in two dimensions. There are three varieties: one point, two point, and three point. See examples below.



1-Point Perspective　2-Point Perspective　3-Point Perspectve

problem solving process (PSP)- (also referred to as *creative problem solving* or the *design process*) consists of a series of logical steps used to solve a problem.

radical - an extreme and unexpected idea. Often the relevance is not immediately visible, because judgment is clouded by conventional concepts.

rendering - a drawing that incorporates color, page composition, and text to completely describe a concept or idea.

sketch - a drawing that is quickly created to describe an idea or concept. Usually drawn freehand.

symbiotic - mutually beneficial

thumbnail sketch - a sketch that is approximately the size of the fingernail on a thumb. Usually takes less than 1 minute to draw.

References

Bellanca, J., & Fogarty, R. (1991). Blueprints for thinking in the cooperative classroom. Palatine, IL: Skylight Publishing.

Bellon, J. J., Bellon, E. C., & Blank, M. A. (1992). Teaching from a research knowledge base: A development and renewal process. New York:Macmillan.

Bruner, J. (1977). The process of education. Cambridge: Harvard University Press.

Butler, K. A. (1988). How Kids Learn: What Theorists Say About Learning Styles. Learning 88. 31-34.

Clarizio, H. F., Craig, R. C., & Mehrens, W. A. (1987). Contemporary issues in educational psychology (5th ed.). New York: Random House.

Clouse, B. (1985). Moral development: Perspectives in psychology and christian belief. Grand Rapids, MI: Baker Book House.

Costa, A. L. (1991). The school as a home for the mind. Palatine, IL: Skylight Publishing.

Davidson, N. (1989). Cooperative learning in mathematics: A handbook for teachers. Reading, MA: Addison-Wesley.

Dishon, D., & O'Leary, P. (1984). A guidebook for cooperative learning: A technique for creating more effective schools. Holmes Beach, FL: Learning Publications, Inc.

Dunn, R. S. (1983). You've got style--now's the time to find out what it is. Early Years, 5, 25-31.

Finch, C. R. & Crunkilton, J.R. (1989). Curriculum development in vocational and technical education (3rd ed.). Boston: Allyn and Bacon, Inc.

Hilgard, E. R., & Gordon, H. B. (1966). Theories of learning (3rd ed.). New York: Appleton-Century-Crofts.

Hunt, David E. (1982). The practical value of learning style ideas. National Association of Secondary School Principals. 87-91.

International Association for the Study of Cooperative Learning Newsletter. Editors, N. & T. Graves. Santa Cruz, CA.

Johnson, D. W., & Johnson, R. T. (1987). Learning together alone: Cooperative, competitive, and individualistic. Englewood Cliffs, NJ: Prentice-Hall.

Kliebard, H. M. (1987). The struggle for the American curriculum, 1893-1958. New York: Routledge.

Koberg, D., & Bagnall, J. (1981). The revised all new universal traveler. Los Altos, CA: William Kaufmann Inc.

Lefrancois, G. R. (1988). Psychology for teaching (6th ed.). Belmont, CA: Wadsworth Publishing Co.

Mergendoller, J. R., & Marchman, V. A. (1987). Friends and associates. In V. Richardson-Koehler (Ed.), Educators' handbook: A research perspective (pp. 297-328). New York: Longman.

Miller,J. P., & Seller, W. (1985). Curriculum: Perspectives and practice. New York: Longman.

Sanders, M., & LaPorte, J. (1991). T/S/M integration project. Technology/Science/Math Integration Project funded by the National Science Foundation.

Walker, D. F., & Soltis, J. F. (1986). Curriculum and aims. New York: Teachers College Press.

MODULE 4: TECHNOLOGY

UNIT 1

EXPERIENCES IN TECHNOLOGY

By

Dennis Steele
Columbus North High School

Abstract

This unit is taken from the Experiences in Technology curriculum materials designed during the pilot phase and demonstration site phase of Tech Prep. Only examples of the scope statement and one duty, including its associated tasks, is shown to provide examples of phases 1, 2, and 3 of CBI curriculum development. The materials from which this is taken are available on computer disk as part of the curriculum materials developed at the Columbus site.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

Experiences in Technology

Scope Statement. This course [Experiences in Technology] will provide students with the opportunity to create, experiment, solve problems, and implement using a variety of computerized and/or controller-driven equipment which is representative of equipment used in business and industry. This course will provide unique and beneficial hands-on experience for students interested in careers in engineering, architecture, and a multitude of other technology-related jobs. Because today's youth are facing a complex future, they must understand the technological and industrial systems which provide goods and services to all people.

Experiences in Technology: Phase 1

DUTY A: DEMONSTRATING COMPUTER OPERATIONS

TASK:

1. IDENTIFY THE MAJOR INTERNAL COMPONENTS OF AN IBM COMPATIBLE COMPUTER.
2. USE THE FORMAT COMMAND.
3. USE THE COPY COMMAND.
4. PERFORM DISK MANAGEMENT OPERATIONS. (MS-DOS and/or Macintosh Computer Operations)
5. MANIPULATE VARIETY OF DATA INPUT DEVICES. (Macintosh Computer Operations)
6. USE VARIOUS DESK ACCESSORY APPLICATIONS.
7. PERFORM DISK MANAGEMENT OPERATIONS.

DUTY A: DEMONSTRATING COMPUTER OPERATIONS
(MS-DOS Computer Operations)

TASK 1: IDENTIFY THE MAJOR INTERNAL COMPONENTS OF AN IBM COMPATIBLE COMPUTER.

PERFORMANCE OBJECTIVE:

Given a list of the internal components and reference materials, the student will identify and explain the function of the major internal components of an IBM compatible computer.

CRITERION-REFERENCED MEASURE:

The student will identify and explain the function of 90% of the components on the list.

PERFORMANCE GUIDE:

Student will:

1. Disassemble IBM compatible computer and identify its major components.[1]
2. List major internal components of the computer and define their function.
3. Reassemble IBM compatible computer and check computer for correct operation.

---

[1] Components are: Central Processing Unit, On/Off Switch, Power Supply, Mother Board, Disk Controller Card, Floppy Disk Drive, Hard Disk Drive, Video Card, Serial/Parallel Communications Card, and Network Interface Card (Keyboard and Monitor will not be disassembled.)

DUTY A: DEMONSTRATING COMPUTER OPERATIONS
(MS-DOS Computer Operations)
TASK 2: USE THE FORMAT COMMAND.

PERFORMANCE OBJECTIVE:

Given four different types of diskettes and reference materials, the student will explain how a computer writes (stores) data on a diskette, reads (retrieves) data from a diskette, and be able to format diskettes in the correct setting for diskette used.

CRITERION-REFERENCED MEASURE:

The student will explain how a computer reads and writes data on a diskette with 80% accuracy and will format correctly each (100% accuracy) diskette received.

PERFORMANCE GUIDE:

Student will:
1. Show how a computer reads and writes data on a diskette.
2. Use the Format Command to format high density and low density diskettes. (Both 3-1/2" and 5-1/4" diskettes)
3. Use the Volume name command and System transfer command when formatting a diskette.

DUTY A: DEMONSTRATING COMPUTER OPERATIONS
(MS-DOS Computer Operations)
TASK 3: USE THE COPY COMMAND.

PERFORMANCE OBJECTIVE:

Given diskettes, list of files to copy, and reference materials, the student will select the correct Copy command to perform required copy task.

CRITERION-REFERENCED MEASURE:

The student will copy all of the files as listed with 100% accuracy.

PERFORMANCE GUIDE:

Student will:
1. Copy a diskette from a floppy drive to a hard drive.
2. Copy a diskette from one floppy to another diskette.
3. Copy a file from a floppy drive to the hard drive.
4. Copy a file from a hard drive to the floppy drive.
5. Copy a file from one diskette to another diskette.
6. Copy a file from one directory to another directory on the hard drive or floppy diskette.

DUTY A: DEMONSTRATING COMPUTER OPERATIONS
(MS-DOS Computer Operations)
TASK 4: PERFORM HARD DRIVE MANAGEMENT OPERATIONS.

PERFORMANCE OBJECTIVE:

Given a list of files, directories, and reference materials, the student will list files in directories, create and remove directories, and erase and rename files as needed.

CRITERION-REFERENCED MEASURE:

The student will complete all of the items on the list with 100% accuracy.

PERFORMANCE GUIDE:

Student will:

1. Use the Directory command.
2. List directories on floppy drive while working from hard drive.
3. List directories on hard drive.
4. List only files with the same extension.
5. Change from hard drive to floppy drive as working drive.
6. Change directories.
7. Create new directories.
8. Create sub-directories within a directory.
9. Erase (delete) files.
10. Rename files.
11. Remove directories and sub-directories.
12. Use the Check disk command.
13. Use function keys on DOS compatible keyboard.

DUTY A: DEMONSTRATING COMPUTER OPERATIONS
(DOS and/or Macintosh computer operations)
TASK 5: MANIPULATE VARIETY OF DATA INPUT DEVICES.

PERFORMANCE OBJECTIVE:

Following a demonstration of the input devices listed or similar, the student will name five (5) data input devices and state their applications.

CRITERION-REFERENCED MEASURE:

The student will name five (5) data input devices and state their applications with 100% accuracy.

PERFORMANCE GUIDE:

Student will:
1. Use the keyboard to input data.
2. Use the mouse to assist in data input and manipulate software.
3. Use the digitizer in the CAD software to help manipulate data input.
4. Use a phone line modem to send and receive data to and from a remote location.
5. See Duty E, Task 4.

DUTY A: DEMONSTRATING COMPUTER OPERATIONS
(Macintosh computer operations)
TASK 6: USE VARIOUS DESK ACCESSORY APPLICATIONS.

PERFORMANCE OBJECTIVE:

Following a demonstration of the desk accessories and given reference materials, the student will list six (6) desk accessories and explain their function.

CRITERION-REFERENCED MEASURE:

The student will list six (6) desk accessories and explain their function with 100% accuracy.

PERFORMANCE GUIDE:

Student will:
1. Use the Find File to find location of files.
2. Use the Chooser to select correct printer location.
3. Use the Calculator, Calendar, Control Panel, and Note Pad when necessary.

DUTY A: DEMONSTRATING COMPUTER OPERATIONS
(Macintosh computer operations)
TASK 7: PERFORM Diskette MANAGEMENT OPERATIONS.

PERFORMANCE OBJECTIVE:

Given a diskette, list of files, list of folders, and reference materials, the student will list folders and files; create, move, rename, and remove folders; and erase, rename, and move files as needed.

CRITERION-REFERENCED MEASURE:

The student will complete all of the items on the lists with 100% accuracy.

PERFORMANCE GUIDE:

Student will:

1. Format a 3-1/2" diskette.
2. Open and close folders and applications with mouse-click method and pull-down menus.
3. Copy or transfer files and folders.
4. Copy a diskette from a floppy drive to a hard drive.
5. Copy a diskette from one floppy to another diskette.
6. Copy a file or folder from a floppy drive to the hard drive.
7. Copy a file or folder from one diskette to another diskette.
8. Copy a file from one folder to another folder on the hard drive or floppy.
9. List folders and files.
10. List folders on hard drive and floppy drive.
11. Change from hard drive to floppy drive.
12. Make a new folder.
13. Save files from application program to their folders.
14. Erase (trash) files.
15. Rename files and folders.

Technology Preparation Proficiencies (sample)

HENDERSON, JEFFRY

SOCIAL SECURITY NUMBER: 309-00-1234
SCHOOL YEAR OF COMPLETION: 1991-92
PROGRAM AREA COMPLETED: EXPERIENCES IN TECHNOLOGY
TOTAL HOURS OF INSTRUCTION: 360

E = EXCELLENT	The student understands the concept and can perform all of the tasks relating to the duty without supervision.
G = GOOD	The student understands the concept and can perform a majority of the tasks at minimum competency levels.
A = ACCEPTABLE	The student can perform some of the tasks needed to complete the duty but requires supervision. Additional training and practice will be needed.
I = INTRODUCED	The material has been presented through a variety of instructional methods, including applications. The student is involved in the skill development process, but has not reached a minimum competency level.

Duties Completed	Proficiency Level
DUTY A: DEMONSTRATING COMPUTER OPERATIONS	E
DUTY B: PERFORMING COMPUTER AIDED DRAFTING (CAD)	E
DUTY C: APPLYING COMPUTER AIDED DRAFTING/ COMPUTER AIDED MACHINING (CAD/CAM)	E
DUTY D: PERFORMING CNC MACHINING	I
DUTY E: USING BUSINESS AND PERSONAL SOFTWARE APPLICATIONS	E
DUTY F: DEMONSTRATING HYDRAULICS AND PNEUMATICS	E
DUTY G: DEMONSTRATING ROBOTIC APPLICATIONS	G
DUTY H: DESCRIBING AUTOMATED MANUFACTURING	E

Date: __________ Instructor:____________________________

Dennis Steele

MODULE 4: TECHNOLOGY

UNIT 2

INTEGRATED MATERIAL HANDLING

By

Tony Suba
Technology Teacher
Ben Davis High School

Abstract

This technology unit integrates activities in mathematics, science, and communications during the development of concepts on material handling.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

INTEGRATED MATERIAL HANDLING

Introduction

The integrated material handling unit is a step by step procedure for demonstrating competency based instruction (CBI). Competency based instruction has two key terms, duties and tasks. Nearly all occupations have a job description that explains assorted duties and task. These duties may range from as few as ten to as many as fifteen per occupation and are determined by the employer.

Tasks are activities that must be performed to complete a duty. For example, a duty stated as, "moving materials between machine operations" might have as one of its tasks, "Using available resources, determine whether pneumatics, hydraulics, motors, pulleys, belts, robots or other such items will provide a means to perform the required duty."

An important part of identifying duties and tasks is the selection process which is to be conducted by your advisory committee. The advisory committee should include parents, secondary teachers, postsecondary teachers, counselors, and business/industry representatives. Remember, developing curriculum in this manner provides a valuable alliance for community support.

The physical layout of this unit is a page with the unit plan that states duties, tasks, performance objectives, criterion referenced measure, performance guide, resources, and requirements. The unit plan provides a method for determining lesson plan layout and teaching methodology. After viewing the unit plan, the lesson plans again list duties, tasks, day numbers, outlines, resources, and degrees of acceptable performance. These terms are defined in the glossary at the end of this unit plan. Day numbers provide performance guide numbers and reflect instructional sequence. Following each page of the lesson plan there are assorted materials to help the instructor and items that the student should receive. Realizing that schools have varied resources, the unit was developed to work with those that have high tech equipment and those that do not.

Suggested Competencies[1]

A. Distinguish between computer and manual control devices.
B. Identify various applications of manual and computer control devices.
C. Determine processing and utilizing of materials.
D. Demonstrate management competency of various technology fields.
E. Identify/demonstrate automated systems and control.
F. Identify means of communicating and processing of information.
G. Identify impacts of present technology.
H. Identify major components of a system.
I. Define technical terminology of various technologies.
J. Define the human interface with various technologies.

---

[1] These competencies were a product of a state sponsored Tech Prep retreat held at Brown County State Park.

K. Develop material handling specifications for the various technologies.
L. Determine various methods of measuring.

Integrated Activities Matrix

Related Academic Skills involved in each task

M = Math C = English/Communications S = Science T = Technology

DUTY: AUTOMATED MANUFACTURING MATERIAL HANDLING PROCESSES

1. Record/List possible solutions from Brainstorming session.
    - Example: A composite list of all ideas prioritized and the top four presented to class. (written/verbal material) C
2. Draw/Sketch models from brain storming activities.
    - Example: Sketch each of the final four models. Include material list measurements, and timeline for development .... T
    - Example: Measurement on ruler or scale and determine length and width .... M
3. Select a brain storming sketch and construct prototype model.
    - Example: Begin actual model assembly .... T
    - Example: Enter data on log sheet each day to asses development. (written statement and paragraph) C
4. Conduct experiments, record results, and adjust/fine tune prototype.
    - Example: Adjust, modify, correct, change to produce a more productive unit ... T
    - Example: Determine mass of material being moved .... S
    - Example: Calculate speed and frequency .... M
    - Example: Fill out log sheet and use table information to form a one page written summary paper. Begin developing rough outline of standard operating procedure (S.O.P.) C
5. Conduct time and motion study to determine operational feasibility.
    - Example: Compile the experiment data and prepare prototype to be presented for possible production .... T
    - Example: Determine what area mechanical, electrical, etc that the device evolve from and total amount of mass moves .... S
    - Example: Formula and time table to present a graph chart or table of experimental results .... M
    - Example: Develop an outline of a final group presentation that uses the log sheet and data collection. Finalize standard operating procedure for general review ... C

Material Handling Unit

DUTY: Automated manufacturing material handling processes

TASK: Design a device to move a product from conveyor systems at different heights.

PERFORMANCE OBJECTIVE:

With materials available, the student will devise a method to move a product between two points.

CRITERION-REFERENCED MEASURE:

The student will perform the assigned tasks and produce a working model to demonstrate 100% mastery or provide a sketch with a prototype model to achieve 70% competency.

PERFORMANCE GUIDE:

The student will:

1. Record/List possible solutions from the brainstorming session.
2. Draw/Sketch models from brain storming activities.
3. Select a brain storming sketch and construct a prototype model.
4. Conduct experiments, record results, and adjust/fine tune prototype.
5. Conduct time and motion study to determine operational feasibility.

REQUIREMENTS:

All students will be assign to a group and perform each activity/assignment.

RESOURCES :

Ben Davis High School demonstration site, Tony Suba, Technology Teacher

Overview of Conveyor Belts[2]

Conveyor systems are used for mechanical handling of materials, either bulk or packaged. **Bulk handling** is the movement of materials in mass or loose forms such as coal, grain, ores, sand, or gravel. **Package handling** is the control of materials that have been put into some type of container.

Conveyor belts can be used to transport bulk materials. The most commonly used belts are made of canvas, rubber, or a plastic material. The conveyor belt is actually a system; it is made up of several parts.

The belt is the main component. It can be made of various materials, depending on the way it is to be used and what it will be moving. Belts are used to carry small parts or small bulk materials such as sand, and are made of finely woven materials such as canvas, rubber, or plastics. The finely woven belt is needed to keep the small parts or particles from falling through the belt.

Woven wire belts are used where the belt must run through extreme temperatures such as those in a bakery or restaurant. In the bakeries, the loaves of bread are put into pans. Woven wire belts carry the pans of bread dough through the oven, moving at a set speed so that the bread is baked when it comes from the oven. Woven wire belts are also used to transport materials through spray booths, or to allow liquids to drain from objects. When the circulation of air is important, the woven wire belt is the preferred choice.

Large rollers, called terminal rollers or pulleys, are used at the end of a conveyor belt. These rollers can be connected to electric motors which provide the power to move the conveyor belt.

Rollers are needed in a conveyor system to support the belt and keep it running straight. These rollers are not powered and, thus, are called idler rollers. They **idle** or are unpowered. Some idler rollers shape the belt into a trough shape so that loose materials will not fall off the edges. This is usually done when transporting materials such as sand, gravel, ores or coal.

It is necessary to keep the conveyor belt tight on the rollers. This often is done by a **gravity** take-up. This device is placed in the lower or return part of the belt. The weight on the take-up pulls the belt tight and keeps an even tension on it.

Some conveyor belt systems are made for special uses. Slat conveyors are used to transport packages or large items. Wooden or metal slats are used instead of the woven belt. Slats are fastened to a chain which turns around gear sprockets. Usually the chain is supported by some type of guide or trough. Rails can be placed along the sides of the slat conveyor to prevent the materials from falling off.

---

[2] Adapted from Bame & Cummings, 1988, pp. 192-196.

Roller conveyors are used for heavy and complex applications such as those found in steel mills, used to move large pieces of metal or in a foundry, used to move large castings. Roller conveyors are also good when it is necessary to stop materials on the conveyor. Roller conveyors can be made in short sections so they can be taken apart and moved. This makes them useful in loading and unloading trucks or train cars.

Some roller conveyors can be powered by electric motors, making it possible to move materials up an incline or horizontally.

Often it is necessary to move materials vertically from one floor of a plant to another or to the top of a machine. Bulk materials are often carried in vertical elevators or **conveyor-elevators.** Buckets are suspended between two endless chains running on rollers. The buckets carry the bulk material vertically and then are tipped over so the material is dumped into a hopper or onto a belt, which carries it horizontally.

Screw conveyors are used to transport bulk materials of fine and medium diameter. The screw conveyor has a long screw mounted in a trough or pipe. As the screw turns, the material is pushed forward by the sides of the feed screw. Screw conveyors are used where accurate amounts of material must be moved. The screw conveyor also helps break up materials that tend to pack or form lumps.

Another type of conveyor is called an **escalator.** An escalator is actually a conveyor system. It is designed so it forms a moving stairway for people. It makes it much easier for people to move from one floor to another in a building. If the escalator should stop running, the steps still can be used as a stairway.

Finally, a common conveyor system that many people have ridden on is called a **moving way.** The moving way is a conveyor belt that has been designed to transport people. Some modern airports use the moving way to transport people between ticket counters or baggage areas and the airplanes. Often it is a long distance from the ticket counter to the waiting room or the boarding gate.

Overview of Just-In-Time (JIT)[3]

Just-in-time or JIT, as it is commonly referred to in manufacturing, is an uncomplicated concept. Just-in-time offers firm and calculated control over production and inventory levels. Additionally, you don't need high powered computers to run or control it in some organizations. The reason behind JIT is two-fold: First, JIT influences higher quality and productivity. Secondly, it dispenses visibility of results, so employee responsibility and dedication are intensified. The benefits of JIT extend beyond the production floor or warehouse. They go forward to the distribution network and backward to the suppliers for the company. For example, manufacturing companies have always ordered materials and supplies in large quantities before they were needed. These materials and supplies were then stored in nearby warehouses and delivered to the plant when needed. Renting a warehouse, storing supplies, and moving supplies from the warehouse can be expensive. Since **CIM** (Computer Integrated

---

[3] Adapted from Komacek, in press, p. 159.

Manufacturing) helps a company know just when it needs certain supplies or materials, the company can have supplies delivered just in time at the plant. This saves the company money that would have been spent to rent the warehouse. Also, the company will finish the products and deliver them to the market immediately. This saves the costs of storing finished items in the warehouse.

Design Brief: Automated Manufacturing Material Handling Processes

Problem:

The age of automation has presented many new manufacturing problems. One of the most common problems is moving a part from one level to another without lost of time or production. Your assignment is to move a part 1/2" X 1/2" X 1/2" from a conveyor belt on one level to another conveyor belt that is six inches higher. During the process you may prepare the mechanism for each cycle but not assist once the design is triggered.

Situation:

The manufacturing staff have determined the following design criteria:

1. The brainstorming session should have a minimum of four different solutions.
2. Safety is a concern and must be incorporated at all times.
3. The design is to be for a tabletop conveyor belt system.
4. The design needs a minimum of two moves.
5. The design device can be triggered by manual, electronic, pneumatic or related methods.

Results:

A list of all ideas prioritized and the top four presented.

Daily Lesson Plan - Day 1

DUTY: Automated manufacturing material handling processes
TASK: Design a device to move a product from conveyor systems at different heights.
DAY: 1 Record/List possible solutions from brain-storming session.

LESSON PLAN OUTLINE

In addition to the design brief, we should remember that the design process is a problem solving journey. The following steps will help in developing a solution:

1. Think first - judge later.
2. The wilder the idea the better.
3. Quantity is wanted.
4. Combine, improve, and expand ideas.
5. Evaluate your ideas.
6. Do something about it!

Direct the class activities as specify below:

1. Discuss and assign cooperative learning groups.
2. Read and discuss conveyor belt article.
3. Read and discuss Just In Time.
4. Begin design brief activity.
5. Related math (speed formula) and science (gear/pulley) concepts.

MINIMUM: Use two boards to simulate conveyor layout.
SATISFACTORY: Using one board and conveyor for layout.
EXCELLENCE: Using two conveyor belts and/or electronic pneumatic devices.

Daily Lesson Plan - Day 2

DUTY: Automated manufacturing material handling processes
TASK: Design a device to move a product from conveyor systems at different heights.
DAY 2: Draw/Sketch models from the brain storming activities.

LESSON PLAN OUTLINE

The following material should be covered and discussed:

o Using the attach grid sheet, sketch each of the final four models. This should include material requirement, measurements and time line for development.

MINIMUM: Graph paper and pencil.
SATISFACTORY: Computer generated list and sketches.
EXCELLENCE: Computer generated list and sketches with action plots for consideration.

Daily Lesson Plan - Day 3

DUTY: Automated manufacturing material handling processes
TASK: Design a device to move a product from conveyor systems at different heights.
DAY 3:Select a brain storming sketch and construct prototype model.

LESSON PLAN OUTLINE

The following material should be covered and discussed:

- With the final four sketches determine which model your group will construct.
- Materials may be limited but remember that substitutes can be found. The recorder will log progress on the project, noting major accomplishments or revisions. These notes should be logged using the log sheet provided.

MINIMUM: Paper model.
SATISFACTORY: Material construction using available material.
EXCELLENCE: CAD/CAM 3 Dimensional model.

Log Sheet

Group:

Date:

Time:

Description of accomplishment :

Group daily comment statement:

Group statement explaining what other classes will help on the development of this device:

Daily Lesson Plan - Day 4

DUTY: Automated manufacturing material handling processes
TASK: Design a device to move a product from conveyor systems at different heights.
DAY 4:Conduct experiments, record results, and adjust/fine tune prototype.

LESSON PLAN OUTLINE
The following material should be covered and discussed:

The group is to develop a chart or graph showing the following titles:

1. The number of objects moving on a conveyor belt for one cycle.
2. The number of objects moving on a conveyor belt for one cycle with successful transfer.
3. The number of objects moving on a conveyor belt for one cycle without successful transfer.
4. Conveyor belt speed for one cycle.
5. Number of times transfer device is engaged.

Several math, science, communication, and technology concepts will be used to perform these functions.

MINIMUM:	Hand construct table and record results.
SATISFACTORY:	Computer generated table and records.
EXCELLENCE:	Data sheets converted to graph and spread sheets.

A Suggested Table or Chart for Use in a Time and Motion Study

	# Moving	# Success Transfers	# Unsuc'ful Transfers	Belt Speed	# Times Engaged
Cycle 1					
Cycle 2					
Cycle 3					
Cycle 4					
Cycle 5					

437

Daily Lesson Plan - Day 5

DUTY: Automated manufacturing material handling processes
TASK: Design a device to move a product from conveyor systems at different heights.
DAY 5:Conduct time and motion study to determine operational feasibility.

LESSON PLAN OUTLINE
The following material should be covered and discussed:

The group is to develop a table to provide data for the following information:

1. The number of times device is engaged.
2. The number of parts moved per minute.
3. Total time involved in transfer sequence.
4. Estimated cost savings.

The group will present a log and a final presentation of the transfer device. This will be done in a class situation.

Communication skills will be a key factor in this activity.

MINIMUM:	Results recorded on a table sheet.
SATISFACTORY:	Data stored and compiled on computer system.
EXCELLENCE:	Data converted to computer spread/graph sheet with report on results.

A Suggested Table or Chart for Use in a Time and Motion Study

	# Moving	# Success Transfers	# Unsuc'ful Transfers	Belt Speed	# Times Engaged
Cycle 1					
Cycle 2					
Cycle 3					
Cycle 4					
Cycle 5					

Homework

These activities are suggested as creativity assignments that students can perform outside of class. Choose only those activities that will reinforce student understanding .

Lesson Plan Day One

1. Develop and present a list of local industries that use automated material handling devices.
2. Research and present a speed formula to determine conveyor belt movement.

Lesson Plan Day Two

1. Develop a one page picture story of how conveyor belts move material. Pictures may be acquired from newspapers, journals, magazines, etc.

Lesson Plan Day Three

1. Clip articles concerning conveyor belts from newspapers, journals, magazines or other such sources and write a summary paragraph. These articles will be posted on a bulletin board for public viewing.

Lesson Plan Day Four

1. Using a traffic light determine the number of vehicles between signals. Observe the traffic light at least four times. Record this information and develop a graph which will show a consistence known as a duty cycle.

Lesson Plan Day Five

1. Using the data from the lab experiments,each individual in the group will be responsible for assembling a part of the final presentation.

Glossary

Chief analyst - The individual who is responsible for studying and correcting the written description of the recorder.

CIM - Is referred to as Computer-Integrated Manufacturing. The use of computer technology to integrate manufacturing activities and control all the elements of manufacturing with a central computer system.

Competence - Defined as duty and associated tasks related to job performance.

Competency based instruction (CBI) - Referred to as a list of duty and task.

Criterion-referenced measure - The established minimum and maximum acceptable levels of student performance.

Data tables - A suggested sheet to record data.

Duty- A topic related to an occupational job area.

Encourager - The individual who is responsible for encouraging all personnel to perform assigned task.

Experimenter - The individual who is responsible for designing and completing all lab records.

Facilitator - The individual who is the leader and who is responsible for the group's results.

Flexible Manufacturing Cell (FMC) - A group of related machines which perform a particular process or step in a larger manufacturing process. A flexible manufacturing cell may also be part of a larger flexible manufacturing system tied together by an automated material handling system controlled by a computer system.

Just In Time manufacturing (JIT) - A manufacturing concept that means parts or materials are delivered at correct time intervals and quantities.

Minimum: The least amount of material required to perform an activity.

Satisfactory: The average amount of material required to perform the activity.

Excellence: The above average access to high tech equipment or materials.

Log sheet - A sheet used to record the groups activities and progress.

Inter-curricular Matrix - Shows relationship with other related academic skills.

Glossary (cont.)

Performance guide - The list of tasks the student is to perform.

Performance objectives - The projected outcome the student will be asked to perform.

Prototype - A model that simulates all functional and aesthetic aspects of manufactured good. This requires more work before final production.

Recorder - The individual who is responsible for collecting notes from the group activity.

Resources - List of available material for instructor or student.

Requirements - The structure of the class and student assignments or activity needs.

Task - A series of activities to accomplish a specific duty.

References

Printed Material

Amatrol, Inc. (1987). Basic pneumatics. Jeffersonville, IN: Author.

Amatrol, Inc.. (1988). Basic hydraulics. Jeffersonville, IN: Author.

Bame, E. A., & Cummings, P. (1988). Exploring technology. Albany, NY: Delmar Publishers.

Blank, William E. (1982). Handbook for developing competency-based training programs. Englewood Cliffs, NJ: Prentice Hall, Inc.

Cackowski, F. (1991). Problem solving strategies. Paper presented at the meeting of the Indiana Industrial Technology Education (IITE) Conference, Hobart, IN.

CNC Software Inc. (1992). Mastercam. Gig Harbor, WA: Author.

Delmar Publishers. (1974). Blueprint reading & sketching. Albany, NY: Author.

Eshed Robotic. (1982). Scorbot ERIII user's manual. Princeton, NJ: Author.

Eshed Robotic. (1989). Scorbot computer integrated manufacturing lab manual. Princeton, NJ: Author.

Hacker, M., & Barden, R. (in press). Living with technology. Albany, NY: Delmar Publishers.

Hoke, R., Competency Based Instruction, AVA Workshop, MSD Wayne Township, 1220 S. High Sch. Rd., Indpls., IN 46214.

Indiana Association of Area Vocational Districts, Inc. (IAAVD). (1992). Competencies-based instruction. Speedway, IN: Author.

Komacek, S.A. (in press). Production technology. Albany, NY: Delmar Publishers.

Miller, R., & Culpepper, F. (1991). Electricity and electronics. Albany, NY: Delmar Publishers.

Video

Modern. (1990). Race against time [videotape]. St. Petersburg, FL: Distributor.

Modern. (1991). The challenge of manufacturing [videotape]. St. Petersburg, FL: Distributor.

Addresses of Distributors

Delmar Publishers, 2 Computer Dr. West, Box 15-015, Albany, NY 12212-5015.

CNC Software Inc., 2909 71st. Ave. N.W., Gig Harbor, WA 98335.

Amatrol Inc., PIO. Box 2697, Jeffersonville, IN 47131.

Eshed Robotic, 445 Wall St., Princeton, NJ 08540.

Modern, 5000 Park St. North, St. Petersburg, FL 33709.

MODULE 4: TECHNOLOGY

UNIT 3

ENVIRONMENTAL DESIGN

By

Paul Modlin
Technology Teacher
Mishawaka High School

Abstract

This unit involves students in the design and testing of a water purification unit suitable for home use.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

ENVIRONMENTAL DESIGN

Introduction

The objective of the technology teacher is to cooperate with teachers of English/language arts, mathematics, and science to structure classroom and laboratory activities. The following unit, CAD/design, integrates with science to study water pollution and methods of improving water quality. The goal is to develop a water purification device.

Tech Prep Drafting/CAD and the Design Process

DUTY: Design a device which would remove unwanted contaminants from drinking water.

TASK: Design a device for removing particulates from water.

PERFORMANCE OBJECTIVE: Through problem solving and design analysis the student will design and present a device to remove particulates from water.

CRITERION-REFERENCED MEASURE: The student will perform the assigned task and produce a set of drawings which includes preliminary design ideas, two orthographic drawings, a perspective, a model, and an orthographic production drawing which contains details, a bill of materials, and a list of specifications in order to demonstrate 100% mastery. 70% mastery is achieved by completing everything up to and including the model.

PERFORMANCE GUIDE: The student will:

1. Record possible solutions to the design problem from the brainstorming session.
2. Formulate "thumbnail" sketches of preliminary ideas.
3. Choose two preliminary ideas and refine them into two separate rough sketches.
4. Develop an orthographic drawing of the best idea.
5. Create a perspective/rendering of the idea.
6. Construct a "sketch" model.
7. Produce an orthographic production drawing which includes details, a bill of materials,and a list of specifications.
8. Construct a functioning prototype

REQUIREMENTS: Students will take complete responsibility for tasks assigned either to individuals or to the group.

Overview of Water Purification

Earth is two-thirds water. Consequently, it is one of the most familiar substances to us. On average, we consume 10 eight-ounce glasses of water every day, and if we consider all of the ways we use water, each of us uses an average of about 150 gallons of water every day!

Virtually all of the water we use is impure. It is obtained from rivers and streams, lakes and reservoirs, or from the ground. Water from all of these sources contains a variety of impurities dissolved in it. Lakes and streams are replenished by rain which is contaminated by air. Much of that "contamination" is desirable. Fish and other aquatic animals can not live without oxygen dissolved in water. Water without gases such as oxygen, nitrogen, and carbon dioxide dissolved in it tastes "flat," and most people don't like it.

Although some of the gases dissolved in rain water are desirable, others are not. Sulfur dioxide, various nitrogen oxides, methane, and many more complex carbon compounds are present in air, and they all dissolve in water to some extent. Most of these gases are undesirable impurities in water. When undesirable impurities are present in water, we say it is "polluted."

Air is not the major source of water pollution. Through runoff from farmlands and household lawns, fertilizer and pesticides (herbicides and insecticides) get into the streams, lakes, and ground water that are sources of our water supply. Soils contain metals such as iron, calcium, magnesium, aluminum, copper, cadmium, and mercury. In fact, all natural metals occur somewhere on Earth and can contaminate water seeping through the soil and rocks that contain them. The July, 1991 issue of U.S. News and World Report reported that "one in six people drinks water with excessive amounts of lead, a heavy metal that impairs children's IQ and attention span." However, the source of lead contamination is usually pipes within your house. Houses built before 1900 often used lead pipes for plumbing and until 1930 most plumbing contained some lead. Until recently lead pipes were commonly used for the connection between the water main and the house. Today lead solder that connects the copper pipes in homes is the most common source of lead contamination.

Organic substances such as gasoline, organic solvents, paints, and dyes can get into water through accidental spills or through seepage from garbage dumps. Because water is such an excellent solvent, there are over 70,000 substances that have been identified as water contaminants. Because there are so many contaminants, they are commonly broken down into five categories of similar substances: biological impurities (bacteria, viruses, and microscopic parasites), dissolved organic compounds (including PCB's and other halogenated compounds), dissolved gases (primarily radon), heavy metal salts (lead, mercury, arsenic, and others), and solid particles (asbestos and other fibers).

Most people obtain water that has been treated by municipal water treatment plants to remove undesirable impurities. However, people in rural areas often depend on untreated water sources, and some people in cities are concerned about contamination that may enter their water supply after it has left the water treatment plant. Both groups are interested in treating water in their home to ensure that it is safe to drink.

Treating water in the home is a complex task. Solid particles and some biological impurities can be removed by filtering, but no filter will remove dissolved gases, dissolved metal salts, or organic compounds. Several different systems are required to remove the various types of contaminants. Table 1 lists several common contaminants and shows what water treatment system is capable of removing each contaminant. Keep in mind that a check in Table 1 simply indicates that the contaminant *can* be removed by a system of the type indicated; it *does not* insure that a *particular* unit of that type will be effective. Also understand that no system is likely to be 100 percent effective. The percentage of a contaminant that is removed by a particular treatment system will depend on factors such as the flow rate of water, how well the unit is maintained, water pressure, the amount of contaminant present, and what other contaminants are in the water.

Table 1
Water Treatment System vs. Common Contaminants

	Ion Exchange (Cation)	Ion Exchange (Anion)	Activated Carbon	Reverse Osmosis	Distillation	Chlorinators	Oxidation and Filtration	Ozonators	Alumina
Arsenic		yes		yes	yes				yes
Barium	yes			yes	yes				
Fluoride				yes	yes				yes
Lead				yes	yes				
Inorganic Mercury			yes	yes	yes				
Organic Mercury			yes						
Nitrate		yes		yes	yes				
Radium	yes			yes					
Radon			yes						
Coliform Bacteria					yes	yes		yes	
Iron	yes				yes	yes	yes	yes	
Odor			yes				yes	yes	
Organics			yes						
Pesticide			yes						
Salt (sodium)				yes	yes				

Before an attempt is made to treat a water supply, the water should be tested in order to determine the type of pollutants that need to be removed. Designing a water treatment system to remove dissolved organic compounds would be useless and unnecessary if none exists in the water being treated.

There are several methods for removing contaminants from drinking water. None is perfect. Most home water treatment systems use one or more of the following methods to remove contaminants: ion exchange, activated charcoal, activated alumina, distillation, reverse-osmosis (Table 1). Chlorinators, ozonators, oxidation and filtration, and ultraviolet irradiation (not listed in Table 1) are used to destroy bacteria and some odor causing compounds, but they do not remove them from the water. As shown by Table 1, all of the treatment methods have limited use. For example, reverse-osmosis will remove mercury, lead, arsenic, salt, some organic chemicals, and some pesticides, but the process will not remove some organic compounds, radon, iron, or some odor causing compounds.

Filtration (not shown in Table 1) is commonly used to remove suspended particles that make water appear cloudy. Many treatment systems use a sediment filter as a pre-filter to remove particles that may damage or reduce the efficiency of the system.

Activated Carbon Filters. One of the most common methods of treating small amounts of water for drinking is filtration through activated carbon (charcoal). Water is forced through the carbon filter, and pollutants adhere to the surface of the carbon. (This process is called adsorption.) Activated carbon has a very large surface area, but once its surface is covered no more contamination is removed. If the filter is not replaced once it is saturated, contaminants can actually be replaced by less noxious substances with the net result that water flowing out of the filter contains more harmful material than the water flowing in. Unfortunately, there is no way to tell when the filter is saturated. Filters are normally changed on a time schedule that is based on the concentration of contaminants in the water supply. Bacteria grow well on activated carbon, so these systems can become a breeding ground for bacteria. However, recent research by the Environmental Protection Agency suggest that bacterial build-up is not a threat to health if the water entering the filter does not contain harmful bacteria.

Activated carbon comes in powdered, granular, and solid block. Powdered carbon is generally not used in home units because it is difficult to design the unit so that water flows well without danger of washing some of the powder along with it. As a rule of thumb, the more carbon in a filter, the longer it lasts, and the longer water is in contact with the carbon, the more effectively it removes contamination. A major disadvantage of activated carbon treatment is maintenance cost. The carbon filters cannot be regenerated easily and must be discarded when they become saturated.

Reverse-Osmosis. Reverse-osmosis uses water pressure to force water through a cellophane-like membrane leaving behind impurities to be carried off in a waste stream. These filters are effective in dealing with lead, inorganic (but not organic) mercury, radium (but not radon), arsenic, nitrates, coliform bacteria, some pesticides and other organic chemicals, and sodium. They do not remove iron, organic mercury, odor, radon, and/or other dissolved gases. Reverse-osmosis systems are quite often paired with activated carbon systems to remove the additional impurities.

One of the main disadvantages of reverse-osmosis systems is that they waste anywhere from one to twelve gallons of water for every one gallon they purify. The effectiveness of the system varies with the membrane used, and depends on the quality of water entering the system. Hard water causes scale to form on the membrane, and some membranes are damaged by iron and sulfides. Because of these factors, it is important to check the effectiveness of the system on the water being treated before investing in the unit.

Distillation. Distillation systems convert water to steam. The steam is then condensed and collected in a storage tank, leaving behind contaminants that will not vaporize. Distillation removes inorganic compounds containing iron, lead, arsenic, mercury, nitrates, and sodium.

Bacteria are either removed or killed when the water is boiled. Distillation does not remove substances with low boiling points such as most pesticides and other organic compounds, radon, and odor causing gases. The major disadvantage of distillation is cost. It takes a great deal of energy to boil water, and unless energy costs are extremely low, the cost of distilled water will be prohibitive except in very small quantities. If the water is to be used for drinking, it is likely to taste "flat," and minerals essential to good health are removed along with objectionable ones.

Ultraviolet Irradiation, Chlorination, and Ozonation. Ultraviolet irradiation, chlorination, and ozonation are quite effective against bacterial contamination. Intense ultraviolet light chlorine, and ozone destroy most microorganisms, and are effective alternative treatments for coliform bacteria. However, chlorine, ozone, and ultraviolet irradiation are useless against impurities such as heavy metals and organic solvents. Consequently, these treatments must be used in combination with other devices if the water is contaminated with anything other than bacteria.

Integration Activities Matrix

M = Math C = Communications/English S = Science T = Technology

1. Discussion of concerns about water contamination	S
2. Health problems of contaminated water	S
3. Types of water contaminants	S
4. Methods of testing water	S
5. Method for removing contaminants from water	S
6. Water purifying systems	S
7. Testing an implementation of device	S
8. Development of a technical manual which includes installation and operational directions	C
9. Calculate the efficiency of the purification system as it relates to the velocity of the water	M

Possible Topics for Discussion

- Discussion of concerns about water contamination
- Health problems from contaminated water.
- Types of water contaminants.
- Purifying systems
    Activated carbon

  - Reverse osmosis
  - Distillation
  - Ultraviolet irradiation
- Outline method for removing contaminants from water.
- Reason for product.
  - Contaminated water
  - Cost of bottled water.
  - Recycling of containers of bottled water.
  - Remove water odor.
- Considerations
  - Water inlet\outlet
  - Container
    - Watertight
    - Replacement of activator
  - Attachment to source
  - Upkeep
  - Material
  - Cost
- Look at existing devices; evaluate and improve; other possible uses or variations
  - Aquarium
  - Outside pond
- Contest to see whose device removes the most pollutants.
- Classes involved
  - Science unit: water pollution/water testing
  - Technical drafting unit: design
  - Vocational machine shop
- Library research: list of topics
  - Water pollution
  - Water purification
  - Water treatment
  - Water filters
  - Water conditioning
- List of people and places to contact
  - Phone book, lumber yards, water conditioning
- Develop work sheet; fill in list for addresses and phone numbers/student contact

DESIGN BRIEF

PROBLEM: Design a purification device which would remove unwanted contaminants from drinking water.

Particular consideration should be given to the following factors:
- Ease of operation
- Ease of installment
- Ease of maintenance
- Available materials and manufacturing processes
- Cost of materials
- Degree of contamination
- Time Available

TECH PREP DRAFTING/CAD DAILY LESSON PLAN - Day 1

DUTY: Problem solving through design analysis.
TASK: Design a device which would remove unwanted contaminants from water.
DAY 1: (Problem Identification) Gather and record all available information about the particular design problem.

LESSON PLAN OUTLINE:
The following material should be covered and discussed:

1. Concerns about water contamination.
2. Methods of removing contaminants from water.
3. Purifying systems.
   a. Activated carbon
   b. Reverse osmosis
   c. Distillation
   d. Ultraviolet irradiation
4. Define design and design analysis

Direct the class activities as specified below:
1. Investigate factors relating to the solution of the design problem.
2. List factors that will determine the overall dimension of the product.
3. Sort data collected from the investigation and define the parameters such as size, strength, materials, tools, cost, etc.

Possible Ideation Topics

What's wrong with it? Make a list of all the things you feel are wrong with the present product, idea, or task.

How can it be improved? Forgetting feasibility, list all the ways you would improve the present product, idea, or task.

Other uses What other uses does it have in its present form? What other uses are there if the idea is modified? Can it perform a function that was not originally intended?

Modify Change trim, size, shape, width, length, strength, weight, form, contours, etc.

Adapt Is there something similar? What can be copied? Can it be associated with something else? Is there something in stock or surplus that can be used?

Rearrange Try a different order, interchange components, piece together differently, change places.

Substitute What can take its place: plastic for metal. Metal for plastic, light instead of dark, round instead of square. What other process, principle, theory, or Method can be used?

Combine Combine ideas, principles, methods, groups, components, hardware.

Convenience Make it easier, less work, easier to reach, disposable, simpler to use, quicker, automatic.

Safety What devices, properties, controls, or sensors can be added to prevent injury, accident, explosion? Make it non-toxic, nonpoisonous, nonflammable, stain proof, non-breakable. Is it safer than a competitor's product, less harmful, less easily cut or torn?

TECH PREP DRAFTING/CAD - Day 2

DUTY: Problem solving through design analysis
TASK: Design a device which would remove unwanted contaminants from drinking water.
DAY 2: (Preliminary ideas) the pupil must gather and list ideas in order to formulate potential solutions.

LESSON PLAN OUTLINE:
The following material should be covered and discussed:

1. The problems parameters.
2. Gathering and listing ideas for possible solutions.
3. Techniques used in recording preliminary design ideas in the form of sketches.

Direct the class activities as specified below:

1. Small discussion groups for problem parameters.
2. Brainstorm for possible solutions.
3. Individual drawings of possible solutions of the design problem in the form of rough sketches.
4. Small group analysis of rough sketches.

TECH PREP DRAFTING/CAD - Day 3

DUTY: Problem solving through design analysis.
TASK: Design a device which would remove unwanted contaminants from water.
DAY 3: (Refinement) Selecting promising ideas for further development.

LESSON PLAN OUTLINE:
The following material should be covered and discussed:

1. Review preliminary ideas
2. Existing purifying systems
3. Techniques in sketching
4. Instrument drawing techniques/cad commands
5. Orthographic drawings

Direct the class activities as specified below:

1. Analyze and select the rough sketch in order to produce a refined sketch to approximate scale.

2. Make an instrument/cad orthographic drawing in order to determine shape, size, and construction techniques.

3. List many different combinations of materials that will solve the design problem.

TECH PREP DRAFTING/CAD - Day 4

DUTY: Problem solving through design analysis.
TASK: Design a device which would remove unwanted contaminants from water.
DAY 4: (Analysis) Evaluate and analyze the designed product to determine if it is functional and appropriate.

LESSON PLAN OUTLINE:

Direct the class activities as specified below:

1. Small group discussion:
   Evaluate and analyze the product designed to determine:
      If the product meets the objective
      If the building process is too complicated or time consuming
      If it is functional and durable
      If the size and shape are appropriate
      If the product is attractive
2. Calculate estimated time and cost
3. Test method of removing contaminants (model)
4. Produce perspective or render drawing using tools/cad

TECH PREP DRAFTING/CAD - Day 5

DUTY: Problem solving through design analysis.
TASK: Design a device which would remove unwanted contaminants from water.
DAY 5: (Decision) Select the best solution based on the analysis of the refined idea.

LESSON PLAN OUTLINE:
Direct the class activities as specified below:

1. Select the best solution based on the analysis of the refined idea.
2. Produce perspective or rendering of product using the proper drafting tools and techniques/or CAD.
3. Present and justify the product to the class.

TECH PREP DRAFTING/CAD - Day 6

DUTY: Problem solving through design analysis.
TASK: Design a device which would remove unwanted contaminants from water.
Day 6: (Implementation) Produce a set of orthographic production drawings. Produce working model.

LESSON PLAN OUTLINE:
The following material should be covered and discussed:

The drawings and techniques that are used to produce a complete set of orthographic production drawings showing details, bill of materials, a list of specifications and an estimated time for production.

The production of a working model.

Possibilities:

Utilize existing facilities
Subcontract to another class

HELPFUL RESOURCES

The following information was taken from Consumer News, "Confessions Of A Water Planet" by Dennis Holmes and Leslie Pardue.

International Bottled Water Association, 113 N. Henry Street, Alexandria, VA 22314 / (703)683-5213. Provides information and test results on bottled water.

National Sanitation Foundation, P.O. Box 1468, Ann arbor, MI 48106 / (313)769-8010. A nonprofit third party testing and certification organization with a certification program for drinking water systems.

National Toxic Campaign, 37 Temple Place, Boston, MA 02111 / (617)482-1477. Operates the nation's only lab focused entirely on testing for communities facing toxic threats. Membership is $25 and includes a quarterly newsletter. Their report, "America's Water Crisis: Fact Or Fiction?" Is available for $1.

Information on water quality and testing may also be obtained from the EPA's safe drinking water hotline: (800)426-4791.

Dennis Holmes works with and does independent research on the alternative drinking water industry. He can be reached at (800)735-6542. (pg. 55)

455

References

Books

Supplying Our Water Needs. (1988). CHEMCOM: Chemistry in the community. Kendall/Hunt Publishing Company.

Magazines

Baker, G. (January, 1971). Teach drafting through design analysis. School Shop.

Green, I. (August, 1988). How to choose a water filter. Popular Mechanics, pp. 117-120.

Summary: Discuses water pollutants and various types of purification systems, including charcoal filters, distillation systems, ultraviolet irradiation, reverse-osmosis units and water softeners.[1]

Holmes, D., & Pardue, L. (January/February, 1992). Confessions of a water planet. Consumer News.

Chemical-Eating 'Bug' To The Rescue. (1990, June). USA Today, 118, No. 2541, p. 3.

Summary: Reports on recent research to discover a type of bacteria that could feed on pollutants. Tests conducted on rhodococcus bacteria which consumes quinoline, a chemical poison that is a byproduct of oil shale and coal processing; value of bacteria as a natural pollution fighting agent.[1]

Schwartz, J. (1989, February 27). Cleaning Up By Cleaning Up. Newsweek. p. 53

Summary: Talks about the growing market for clean drinking water, including bottled water and water treatment equipment. Technologies; equipment; confusion; hucksters; testing. Inset: cashing in big on a gusher (drinking water treatment equipment).[1]

On tap: Safe drinking water. (April, 1988). Current Health 2. pp. 16-18

Summary: Discusses safe drinking water. How drinking water is purified; giardiasis (a disease spread by a protozoan, giardia lamblia); amebiasis (dysentery); How To Check For Safe Drinking Water (at home camping, etc.).[1]

Mueller, W. (July, 1988). A guide to water purifiers. Consumers Research Magazine. pp. 11-17.

Summary: Discussion of concerns about water contamination: statistics on owners on water purifiers and manufactures; health problems from contaminated water; water testing; knowing water contaminants; test prices; how to test; details of four types of

---

[1] All summaries are from Ebsco Abstracting and Indexing, P.O. Box 325, Topsfield, MA 01983

water contaminants; how to select a purifying system; water softeners (caution exchanger); activated carbon (ac); reverse osmosis (ro); distillation; national sanitation foundation certification.[2]

Webendorfer, B. (September, 1988). A drop to drink. Country Journal. pp. 27-33.

Summary: Presents a guide to treatment equipment for rural water problems. Contaminants; activated carbon filters; distillation; reverse osmosis process; options.[2]

Tevis, C., & Freese, B. (December, 1988). Water treatment systems. Successful Farming, pp. 40-41.

Summary: Outlines methods of removing contaminants from family's drinking water. Compares water softener, reverse-osmosis, distiller, chlorinator (dry) and carbon filter water treatment systems.[2]

Video & Software

The following list of resources was taken from the teacher's guide edition of Chemcom chemistry in the community.

"Lake Study." Project seraphim (ap or at 804/$5). Intended to involve non-scientists in scientific exploration by allowing students to collect data and identify the pollutant that is killing fish in a lake. Uses penguin graphics magician. "Pond Study" (ap 809) is a less rigorous version.

"The New Williamette." Free rental from modern talking picture service (no. 10110). 24-minute color 16 mm (or 1/2" vhs). Documents the joint efforts of industry, citizens, and government to clean up the once polluted Williamette River in Oregon, it serves as a model for the cleanup task ahead for other rivers of the world. Producer: U.S. Army Corp Of Engineers.

"Pollute." Cambridge Development Laboratory, Inc., $54.95 (no. 4-deb-054a/Apple, 064t/trs-80,074c/Commodore 64,0841/IBM PC, 094j/IBM PCJR). Interactive simulation which examines the impact of carious pollutants on typical bodies of water. Students consider the impact on oxygen content and fish survival of water temperature, waste type, waste treatment type, rate of waste dumping, and type of receiving body of water. Generates both tabular and graphical data, and enables students to test various hypotheses. Included a teacher's guide and student worksheets. Grades 9-college (more sophisticated than "Water Pollution"). Diversified educational enterprises software.

"Toxic Turmoil: The Silicon Valley Story." Free rental from modern talking picture service (no. 18555). 28-minute color 16mm film (or 1/2"vhs). Describes how leaks from underground storage facilities contaminated ground water, tarnished the clean image of the electronics industry, and caused widespread public concern, this well-balanced documentary examines the sources of the contamination, industry's response to the problem, and the potential health risks involved. Producer: clean water task force. Available only in California.

---

[2] All summaries are from Ebsco Abstracting and Indexing, P.O. Box 325, Topsfield, MA 01983

"Waqual." Project Seraphim (ap, at, co, ib 802/$5). Computer simulation of a waste water treatment plant. Students choose the fraction of waste that will receive primary, secondary,and tertiary treatment and note the effect on the pollution level in river.

"Water." Hawkhill associates, inc. 13 minutes ($29 for videocassette rental/copy-$42 for sound filmstrip). Introduction to the physics, chemistry, and biology of water. Concepts include the shape of the water molecule, heat of fusion and vaporization, function in erosion role as the earth's thermostat and circulatory system, as will as the mystery and beauty of flowing water.

"Water-It's What We Make It." Free rental from modern talking picture service (no. 18395). 18-minute color, 16mm film (or 1/2" vhs) with free discussion material. Focuses on the need for pure water and filtering technologies that con be used to obtain it. Producer: Water Quality Association.

"Water: More Precious Than Oil." 58-minute PBS film; $95 rental. $200 purchase price. Examines the issues of water management and its conservation on a global basis. Producer: KTCA, Minneapolis-St. Paul, MN, 1980.

"Water Pollution" E.M.E., Apple II diskette (wp-a460/$35), TRS-80 diskette (wp-t460/$36.75), and IBM PC/PCjr diskette (wp-m460/$41) with student lab booklets and study guide: interactive simulation allowing students to vary temperature, type of waste, dumping rate, and method or treatment and note the effect on aquatic life. (pp. XXXIII)

MODULE 5:
AN INTERDISCIPLINARY MODULE ON BAR CODING

BACKGROUND FOR TEACHERS

by

Duane D. Dunlap
Assistant Professor of Industrial Technology
Purdue University
Technology

Abstract

This module demonstrates the highest level of curriculum interaction. All primary areas of the curriculum (technology, language arts, mathematics, and science) support one another by giving students the opportunity to see how a single topic can apply to many different aspects of their life.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

BACKGROUND FOR TEACHERS

Introduction

Units in Modules 1 through 4 illustrate how Tech Prep courses might be taught by teachers operating in a conventional classroom environment or by teachers working in teams. None of those units attempt to integrate *all* of the subjects that are part of Tech Prep reform. This module does.

The strategy used to develop this module could be employed to develop a number of interdisciplinary units. After the developers discussed several possible themes, bar coding was selected. The technology teacher provided background on bar coding (essentially the information that follows), and each team member looked for ways that important content in his or her subject might be related to bar coding. Efforts were made to develop lessons that would illuminate the bar coding technology and teach academic content.

The organization of this module differs from the other four. First, a decision was made to emphasize group problem solving in the module. This meant that lessons would be quite open-ended. Rather than present sequenced lesson plans, "Design Briefs" are given. A *design brief* consists of a problem statement, information required to place the problem in context, and, where appropriate, suggestions to get students started on the task at hand. The design briefs have not been sequenced in any way. In a particular classroom, students might move from a technology design brief to a mathematics one to one in language arts.

Since there is no instructional sequence to provide an organizational framework for these materials, they are organized by subject: language arts, mathematics, science, and technology. This organization makes it easy to select materials for possible inclusion in conventional courses as well as in intedisciplinary classes.

This module provides insight into the use of the most common form of automatic identification, bar coding. It describes the various types of hardware and software used to read bar codes, including information on software that will facilitate implementation of bar coding in your own classroom. Suggested classroom activities and addresses of companies that market bar code scanners and printing software are at the end of this section of the module. Bar code shareware programs have been provided to the Tech Prep regional coordinators. One program runs entirely under DOS and the other uses the Microsoft Windows interface. Should you find any of these programs useful, please contact the author to register the software.

We think you will agree that the potential applications of bar coding are virtually endless. Bar coding is fun and productive. You may enjoy this module even more than your students!

Background on Bar Coding

Rate of inaccuracy in human data entry: One in every 300 characters entered by keyboard.

Rate of inaccuracy from bar coded entry: One in 3,000,000 characters scanned.

Bar codes, those little vertical lines seen on all retail goods, have been utilized for over 20 years by the supermarket industry. Bar coding is gaining tremendous use outside the supermarkey industry. Global competition threatens to force virtually all companies, small or large, to "bar code or perish".

Have you checked out a book from your city library or university, only to have it "scanned" before it is handed to you? Some VCR's on the market are programmed through the use of bar codes. Purchased a new car lately? The Vehicle Identification Number (VIN) on the dashboard of that new car is probably bar coded. The use of bar codes has become so diverse that you'll find they are used for everything from tracking cows in the pasture to aligning NASA's largest radio frequency satellite receiving dish.

The retail market--more explicitly, the modern supermarket--pressed the utilization of bar coding into a cost effective and productive technology for collecting accurate data. Serious efforts by RCA in 1968 led a Kroger Supermarket store in Cincinnati to install the first commercial application of bar coding in 1972. In the 1970's the Westinghouse Corporation developed industrial applications of bar coding to tag and identify railroad cars. Bar codes affixed to the exterior side of railroad cars allowed operators to determine content and destination of the cargo.

The term, bar code, is used in three ways when discussing this form of automatic identification technology. *Bar code* can refer to the symbol itself, the information contained in the symbol, or the language used. The *symbol* is the actual physical bar code that appears on the object being scanned. The *code* refers to the information encoded in the symbol. The *symbology* is the language spoken by the symbol. Each bar code symbology has unique characteristics. For example, some symbologies can only encode numbers (numeric), others encode letters and numbers (alpha-numeric). In addition to what a bar code symbology can encode, the symbology can also vary in density and length of the printed code.

Throughout the business and industrial world, bar coding is becoming the sanctioned technique for data entry. When there is a need to track, identify, or enter information into a computer system, the utilization of bar codes has proved to be one of the easiest, most efficient and cost-effective techniques for reaching 98-100% accurate data input.

Automatic identification and automatic data collection. The term *automatic identification* (Auto ID) or *automatic data collection* (ADC) is applied to bar coding and other forms of keyless data entry. Automatic identification refers to the; "systematic data collection by means other than manual notation or keyboard input" (Fales, 1990). The goal of Auto ID is reliable identification of physical objects in real time and in some meaningful detail. When discussing Auto ID, bar coding is only one form of keyless data entry. Other forms of Auto ID include *optical character recognition* (OCR), *magnetic stripe* (Mag Stripe), *voice recognition*, *magnetic ink character recognition* (MICR), *radio frequency identification* (RF/ID), *smart cards*, and *machine vision*.

Reasons for Auto ID. Accuracy, speed, and reliability are the underlying reasons for implementing an Auto ID system. Automatic identification systems are fast. Not only is the input of data quick and dependable, but the information is provided in real time to virtually any database or software package the end-user chooses. This advantage allows the user to make very informed decisions on events that are happening right now. In 1994, about half of all manufacturing and warehousing operations will have some sort of Auto ID system. In 1989, the figure was 15 percent.

Because of supermarket and other retail applications, bar coding is by far the most noticeable form of Auto ID. The number of applications to which bar coding can be applied has led companies to improve production by reducing errors and costs. Bar coding is easy to learn, easy to use, and inexpensive. By reading bar codes, data can be acquired 100 percent faster and 10,000 to 15,000 times more accurately than by any other means of manual input.

Bar Coding Technology

Reading bar codes. "Scanning" and "reading" are used interchangeably in this discussion. Handheld wands are usually referred to as bar code *readers*. *Scanners* commonly have moving optical beams. Bar code scanners read bar codes directly into a computer. Scanners read and then decode the various bar codes automatically. Scanners contain a very intense light source. There are four generic types of scanners based on the illumination of a light source: 1) visible red light emitting diode (LED), 2) visible red helium neon laser (HeNe), 3) visible red laser diode, and 4) invisible red laser diode. The light source is passed over the bar code symbol. The dark bars of the bar code absorb the light, while the spaces reflect the light back into the scanner. The scanner converts the reflected light into electrical patterns or impulses that are decoded and translated into a binary code for transmission to the computer system. All scanners work on the principal of illuminating the symbol and converting the reflected light pattern into an analog signal that is decoded and then digitally processed. The digital signal will be high (1) over a space and low (0) when over a bar.

Scanner types. The different kinds of scanners available can be divided into two groups, either contact or non-contact. Contact scanners are commonly referred to as handheld wedge readers, light pens, or wands. Contact scanners must come in contact with the bar code. The user must physically move the wand across the bar code. Such scanners are the least costly bar code readers and are one of the most popular reading devices available.

Wedge readers typically plug into the keyboard port of a microcomputer. The keyboard connector then plugs into the wedge. The end-user can use the wedge and keyboard simultaneously. Other wedge readers, light pens, or wands plug into a half-height card that is installed into one of the buss slots found on the motherboard of the microcomputer. The light source from a contact scanner can be either visible red or non-visible infrared.

Non-contact scanners can be either handheld or stationary. Handheld non-contact scanners are of the "pistol" or "gun" type. Non-contact scanners have the ability to decode the bar code without making physical contact with the symbol itself. The user points the scanner at the bar code label and pulls the trigger to activate the light source.

The range of scanning is anywhere from 5 inches to 5 feet, depending on the scanning technology used. However, some manufacturers claim the distance a barcode can be successfully scanned is ten times the X-dimension[1]. The big advantage of using a non-contact, handheld laser scanner is the *sampling rate*, the number of times the bar code is scanned each second. Laser scanners can scan from 30-70 times a second. The most common non-contact scanner is the stationary type found at the checkout line in your supermarket.

Common Bar Code Symbologies

The bar code industry uses the term *symbology* to denote a particular bar code scheme, while the term *symbol* refers to the bar code label itself. To encode data, each symbology uses a unique set of rules to determine the type of information (numeric, alphanumeric, or ASCII characters) that will be placed in the symbology. Each one-dimensional bar code is a design of wide and narrow bars and spaces called *elements* that represent the information. Just as the English and Chinese languages have different characters and rules to follow, each symbology (language) has its own set of characters. There have been over 60 different symbologies developed. This module will treat the six most common bar code symbologies found today: Code 39 (3 of 9), Codabar, Code 128, Interleaved 2 of 5 (I 2 of 5), Universal Product Code (UPC), and PostNet.

All symbologies have certain characteristics in common, and they have other unique traits. These characteristics determine whether the encoded information is fixed or variable, and they determine how densely the data can be packed together.

At the beginning and end of all bar codes is a blank space called the *quiet zone.* The purpose of the quiet zone is to trigger the scanner's decoder and software to start looking for a bar code. *Start and stop characters* are distinctive patterns of bars and spaces at the beginning and end of the encoded information within the bar code. Start and stop characters allow for bidirectional reading. One-dimensional bar code symbols can carry their information in the widths of the bars and spaces. Each bar code symbology contains its own bar and space configuration to encode information. Some bar codes, like 3 of 9, have what is referred to as an *intercharacter gap* between each individual character. Each character is printed independently of the others, leaving a space separating each character.

The height of a bar code symbol carries no information. The height of a bar code (one-dimensional or linear) only serves as a measure of vertical redundancy. An exception is the United States Postal Service (USPS) bar code, PostNet (Zip+4). Almost all bar codes contain quiet zones, start/stop characters, a unique bar/space pattern, intercharacter gap, and a human readable line. The *human readable* portion of the bar code is the characters that people can read.

---

[1] The x-dimension is the width of the smallest element of a bar code.

Example of Codabar Symbology

A01234-789$:/.+D

CODABAR requires any of four different start/stop characters consisting of 4 bars (1 bar that is 4 times normal width) and 3 spaces at the beginning and end of the symbol. The four start and stop characters can be used in any order depending upon application. Codabar is used by the medical profession, air parcel express bills (helps Federal Express move over 800,000 packages each night), in libraries, on photo finishing envelopes, and in the baggage handling industry. Codabar encodes a 16 character set which includes numbers (0-9) and the characters "$", ":", "/", ".", "+", and "-". In 1977 Codabar was adopted as the standard symbology for blood bags by the American Red Cross. Codabar is capable of a first pass read of 99% and a substitution error rate of 1 in 1,000,000 reads without a check digit and 1 in 1,000,000,000 with a check digit. Codabar is an excellent symbology for applications where **accuracy is a critical factor**. Codabar is rarely used in manufacturing because it is not alphanumeric and can be difficult to print.

Of important note regarding Codabar:

+ Discrete and self-checking (see glossary) symbology
+ Encodes only numbers except for start/stop codes which are the letters a, b, c, and d.
+ Data characters contain 4 bars and 3 spaces
+ Code can be variable length using up to 32 characters
+ It is a bi-directional code
+ All characters are separated by intercharacter gaps
+ Density of this code can range from 3.6 - 10 characters per inch
+ There is no check digit
+ Quiet zone is typically 10 times the width of the narrow bar
+ A complete Codabar character will have 4 bars per digit.

Example of Code 128 Symbology

Code 128

CODE 128 has 103 bar code characters and can encode the full ASCII character set. In order to do this, Code 128 employs a technique where each character may be interpreted in two or three different ways, according to the code set being used. Three different code sets are defined. Code set A encodes standard punctuation characters, numbers , upper case letters, and computer control characters. Code set B encodes standard punctuation characters, numbers, upper and lower case letters, and special punctuation characters. Code set C encodes two digits for every bar code character from 00 to 99. Special start characters and shift characters in the symbol tell the reader exactly how to interpret the printed symbol. This is one of the major advantages of Code 128. The bar code reader can positively determine which code set is being used and correctly decode the data. Code 128 provides higher density than other established industrial symbologies. This code is more compact, requiring only 68% of the space required by Code 39 characters. For purely numeric data or data containing long runs of digits, Code 128 is the best choice.

Of important note regarding Code 128:

+ Uses alphanumeric characters
+ Begins with 1 of 3 different Start characters and ends with a stop character
+ Start character and data characters are assembled with 3 bars and 3 spaces
+ Stop character is made up of 4 bars and 3 spaces
+ Four widths of bars and spaces are used
+ Code can be variable length
+ Bi-directional scanning
+ Check digits can be used and is a continuous symbology
+ Code density can range from 4.3 - 9.1 characters per inch
+ Quiet zone is 10 times the width of the narrow bar
+ Complete symbol will consist of 1 bar more than an integral multiple of 3 bars.

Example of Interleaved 2 of 5 Symbology

123456

Interleaved 2 of 5 (I 2 of 5) is a high density symbology and one of the most space efficient, one-dimensional symbologies for short numeric data fields (10 digits or less). This code is broadly used in warehousing and on corrugated shipping containers in the distribution industry. This symbology uses a series of wide and narrow bars or spaces to represent each character. The characters are "interleaved" together using the bars to depict data characters occupying the odd positions and spaces for the even positioning. Each I 2 of 5 character actually encodes two digits, one in the bars, and one in spaces.

Of important note regarding Interleaved 2 of 5:

- + Uses numeric characters only
- + Permits bi-directional scanning
- + Contains unique Start and Stop patterns consisting of 2 narrow bars (start) and 1 wide bar, a narrow space, and 1 narrow bar (stop)
- + Each character is composed of 5 elements, 2 of which are wide and 3 that are narrow
- + Data character sets that represent a pair of numeric digits are assembled with 5 bars and 5 spaces, two of which are wide and three that are narrow.
- + Character pairing begins with the most significant digit (left most digit), pairing characters two at a time until all characters are used
- + I 2 of 5 symbols must contain an even number of numeric data characters
- + There is no check digit used
- + The code is self-checking and is a continuous symbology
- + The relative density of this code ranges from 2.3 - 17.8 characters per inch
- + The complete symbol will be made up of 4 bars more than an integral multiple of 5 bars

Example of POSTNET

479071416

The **POSTNET** bar code was developed by the United States Postal Service (USPS) for encoding the five digits of a zip code or preferably, zip code (first five digits) plus 4. POSTNET stands for Postal Numeric Encoding Technique. The use of POSTNET allows the USPS to reduce its direct labor cost of sorting mail by hand to automating its handling by reading it with laser scanners. Some experts do not define POSTNET as a bar code. This is due to the fact that the numbers encoded in POSTNET are not in the width of the bars or spaces. POSTNET is read by clocking the bottom of the bars with a scanner as the individual mail piece with the code moves by the scanner at a predetermined speed. POSTNET is a numeric symbology that consists of nine digits plus a correction digit (check-digit) used by the bar code scanner to identify reading errors. Each numeric digit represented in POSTNET is made up of five bars which comprise various positional arrangements of two tall bars and three short bars. The tall bars represent binary 1's (ones) and the short bars represent binary 0's (zeros). The digits 0-9 are encoded as follows:

0 - 11000
1 - 00011
2 - 00101
3 - 00110
4 - 01001
5 - 01010
6 - 01100
7 - 10001
8 - 10010
9 - 10100

The numeric value of each code (with the exception of 0) may be determined by summing the "weights" of the two positions in each code which are occupied by the ONE bits. From left to right the bit positions are weighted 7, 4, 2, 1, and 0. The complete ZIP plus 4 POSTNET code consists of 50 bars representing the nine digits of the ZIP plus 4 code and the correction digit, plus a framing bar at each end of the string, for a total of 52 bars.

Example of Code 39 Symbology (Referenced in Technology Design Brief II)

BAR CODE 3 OF 9

CODE 39 (3 of 9) is the most dominant, flexible, widely used, standardized and supported industrial symbology used in manufacturing. Code 39 is not only used in manufacturing, but it has been applied effectively in hospitals, libraries, universities, and government agencies. The name Code 39 comes from its 3 out of 9 structure where 3 of the 9 elements are wide and the remaining 6 are narrow in the code's 5 bar and 4 space makeup. The standard Code 39 symbology encodes 44 different alphabetic, numeric, and graphic characters. These characters include numbers 0 through 9, the English alphabet in upper case characters, and 8 special characters ("-", "+", "%", "$", "/", ".", "*", and "space"). It should be noted that the character * (asterisk) is used for the START/STOP character in the 3 of 9 Code. It is possible to encode all 128 ASCII characters in the 3 of 9 Code's FULL ASCII feature. Sometimes this code is referred to as Extended Code 39. Since 3 of 9 Code is discrete and self-checking, it can be reproduced on a variety of printing equipment and different printing processes. Code 39 is promoted and supported by the American National Standards Institute (ANSI), the Automotive Industry Action Group (AIAG), the Automatic Identification Manufacturers Association (AIM) and the LOGMARS (Logistics Applications of Automated Marking & Reading Symbols) study group within the U.S. Department of Defense.

Of important note regarding Code 39:

+ Discrete symbology
+ Can encode 128 ASCII characters
+ Can incorporate alphanumeric characters
+ Code can be variable length
+ Allows bi-directional scanning
+ Start/Stop Character is an * (does not need to be part of the humm readable code)
+ The * consists of 5 bars and 4 spaces at the beginning and end of the encoded data
+ Each data character is constructed with 5 bars and 4 spaces
+ Two of the five bars are going to be wide and at least one of the four spaces will be wide. (44 possible characters in the standard edition)
+ All of the characters are separated by intercharacter gaps
+ Check-digit is optional, but can be used
+ Density can range 3 - 9.4 characters per inch
+ Quiet Zone is 10 times the width of the narrow bar
+ A complete symbol will consist of an integral multiple of 5 bars

Example of UPC-A (Referenced in Technology Design Brief I, and Math Design Briefs I-IX)

012345678905

Universal Product Code (UPC) - was established for the benefit of the food/supermarket industry to facilitate automatic scanning of item numbers with associated price look-up at the point of sale (POS). UPC is also utilized on all retail products sold. The UPC code is a 12 digit, all numeric code typically referred to as UPC-A. The code consists of a number system character, a 5-digit manufacturer identification number, a 5-digit item code number, and a check digit. The UPC code that uses only a 6 digit number is referred to as UPC-E. UPC-E only represents the manufacturer of the labeled item with some stipulations. For example, UPC-E allows companies whose manufacturer identification code contains one or more zeros to encode a limited number of unique product codes within the six digits. UPC-E codes can be found on your favorite beverage can or container.

The first number character, typically located at the lower left side of the bar code and usually out-side the bars and spaces, is referred to as the number system character or data identifier. There are currently seven categories of the number system character: "0" is assigned to **all** items **except** as follows; "2" is designated for random-weight items such as meat and produce, "3" is designated for companies which have been assigned their National Drug Code (drug item) number as their UPC, "4" is designated for retailer use only, "5" is assigned to coupons, "6" and "7" are designated for industrial applications, including retail applications, where they serve the same function as "0". Applications for UPC include retail items and products, packaging, counting, purchase orders, shipping containers, and invoices. UPC and its international supersets, EAN and JAN are totally dominant in POS applications. For international product numbers, EAN/JAN have the capability to have the country origin code predefined. EAN/JAN can encode 13 digits, similar in some respect to UPC-A, and a shorter version (EAN-8) of the code can encode 8 digits. However, their lack of flexibility (only numbers) makes UPC, EAN, and JAN a non-preferred choice for industrial applications.

Important Notes Regarding UPC:

- It codes only numbers from 0 to 9.
- A dark bar with width equal to the x-dimension[2] indicates a binary 1 and a white space of the same width indicates a binary 0. A bar twice the width of the x-dimension represents two binary ones (11), a bar three times the width of the x-dimension represents three binary ones (111), and so forth. In like manner, spaces that are twice the x-dimension represent 00, those that are three times the x-dimension represent 000, and so forth.
- A bar or space may be from 1 to 4 times the width of the x-dimension. Thus a single bar will represent 1, 11, 111, or 1111, depending on its width; a single space will represent 0, 00, 000, or 0000, depending on its width.

---

[2] See the Glossary on pp. 17-18 for a definition of the x-dimension.

- Each digit is coded by 2 bars and 2 spaces occupying a total width 7 times the x-dimension.
- Digits to the left of the center pattern are coded space-bar-space-bar; digits to the right of the center pattern are coded bar-space-bar-space.
- Each digit has two binary codes. One is for the left-of-center pattern and one is for the right-of-center pattern.
- Digit patterns to the left-of-center contain 3 or 5 binary ones and are said to have odd parity. Digit patterns to the right of center contain 2 or 4 binary ones and are said to have even parity.
- The binary number that is used for each number is the binary code, not the binary representation for that number.
- The check digit is the twelfth digit encoded into the symbol. The check digit is not always printed in numeral form.
- Each bar code consists of a right and left quiet zone, a right and left guard pattern, a center pattern, and the twelve number codes.
- The quiet zone on the left is 11 times the x-dimension, and the quiet zone on the right is 7 times the x-dimension.

UPC ENCODING SCHEME

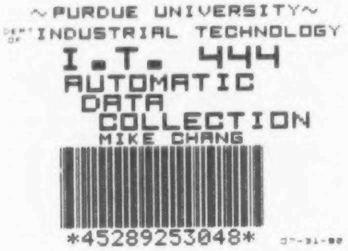
NUMBER VALUE	LEFT CHARACTERS (ODD PARITY)	RIGHT CHARACTERS (EVEN PARITY)
0	0001101	1110010
1	0011001	1100110
2	0010011	1101100
3	0111101	1000010
4	0100011	1011100
5	0110001	1001110
6	0101111	1010000
7	0111011	1000100
8	0110111	1001000
9	0001011	1110100
GUARD PATTERN	101	101
CENTER PATTERN	01010	

Classroom Applications of Bar Codes

The applications of bar coding in the classroom or laboratory are endless. Bar coding can be part of units or lessons in communications, construction, manufacturing, transportation, or even in your Technology Students of America (TSA) activities. For data that are entered on paper continually, in your gradebook, or on your computer, bar coding can come to the rescue. Remember, bar coding is easy, fast, and exponentially more reliable than hand writing.

One of the monumental tasks of any teacher is that of taking attendance. One way to speed this up and provide very accurate records is to have the students print bar code labels that have Student Identification Numbers (SIN's) or Social Security Numbers (SS#'s) encoded. Students can place the bar code label in their notebook (one way to make sure they always come prepared) and scan themselves "in" when coming to class. If you do not want to put the bar code label on a notebook, your students could design an official attendance badge. The badges could be made and printed up in your classroom or laboratory using a high quality dot matrix printer. You might consider laminating the badges before issuing them to students. A word of advice: Print a *couple* of badges first and make sure that they can be read by the scanner after lamination.

Example of Printed SIN



~PURDUE UNIVERSITY~
DEPT OF INDUSTRIAL TECHNOLOGY
I.T. 444
AUTOMATIC
DATA
COLLECTION
MIKE CHANG
45289253048 07-31-88

Another area in which bar coding can make a teacher's job easier is in the area of grading and evaluation. Should you use a spreadsheet or database program to record or calculate grades, use the same SIN's or SS#'s from a class menu sheet. The class menu sheet (an example of a menu sheet is provided at the end of this paper) would not only contain SIN's but also numbers and/or scores for quizzes, tests, drawings, and any other activities. One way to insure student anonymity is to have students stick a bar coded label on their work before submitting it for evaluation. That way, you can go through and grade all the materials and then scan each student SIN and bar code score directly into your electronic grade book.

Bar coding will never replace the grading of papers, but it will help immensely in the data entry and computation of grades. This application takes a process that used to tie up hours each week (manually inputting grades) and reduces it to minutes.

There are other possible applications for using bar coding in your classroom or laboratory. These ideas include:

✓ Property control and inventory

✓ Software, book, or lab equipment management

✓ Checkout system to keep track of tools

✓ Tracking a student's time for progress on a particular assignment or activity

✓ One application under investigation is the notion of using a test or quiz answer sheet with bar codes already printed on it. The student, in response to a question, would circle the bar coded answer of his/her choice. The grader would scan the SIN and all the circled responses on the answer sheet. Your spreadsheet would calculate the score and enter it directly into the correct place in the spreadsheet or database you use.

Troubleshooting

Should your bar code labels not scan or decode properly, check to see if: (1) one or more of the narrow spaces are too narrow and out of specification, (2) poor print contrast between the bar code itself and the substrate material, or (3) the quiet zone at either the beginning or end of the symbol is too short.

Bar Coding in the Future

The future of bar code symbols is that of two-dimensional or stacked bar code symbols. Such bar code symbols are referred to as "portable data files or databases". The article from the New York Times and reprinted by Symbol Technologies (attached at the end of this section) shows how data (Code PDF 417) can be compacted tightly, using less "real estate". Other public domain two-dimensional bar codes include Code 49 and 16K. Code 49 was developed by the Intermec Corporation (Everett, WA) and Code 16K was developed by Monarch Marking (Dayton, OH). Both of these codes arrange data in rows. These codes can be read by traditional scanners but require much tighter printing tolerances than previous one-dimensional bar codes. Two proprietary codes worth noting are Vericode and Data Code. These two codes offer tremendous data security. To the human eye, they look like a square with numerous blocks and rectangles inside it, with the pattern conforming to no sequence or design that is recognizable.

Example of Code 49.

Glossary

The ***aperture size*** of a scanner is the size of the opening for the optics which controls the area of the bar code symbol that the scanner can "see" at any one time.

Check-Digit is a character that is included with the encoded information for the purpose of performing a specific, pre-set mathematical check to ensure the accuracy of the message.

Continuous Code symbologies begin with a bar, end with a space, and waste no space between characters. The inter-character space is part of the symbology structure. The spaces in the symbology are all part of characters (i.e. I 2 of 5).

The ***depth of field*** for a scanner is the range in distance from the symbol (both minimum and maximum) that the scanner can read the X dimension. Put another way, it is the distance from the symbol in which a bar code is in focus for the scanner to read. For example, if a laser scanner can read a bar code anywhere from four inches to twelve inches away, then the depth of field is eight inches. Contact wands have a very small depth of field, typically around .065 inches.

A ***Discrete Code*** is one in which the spaces between characters (inter-character gap) are not part of the message encoded by the symbology. These spaces can vary dimensionally within tolerance limits. Opposite of continuous type codes.

An ***Element*** is a bar or space in a bar code symbol.

First Read Rates (FRR) is a ratio of the number of times a bar code is decoded during the first read or pass, divided by the number of attempts or tries it took to read the bar code. Any bar code system should have at least a 85% FRR and at least a 99% second read rate. Nine out of ten times when the bar code does not decode, the bar code symbol itself is somehow obscured or the print quality of the bar code is poor. This, in turn, lowers the FRR.

Inter-character Gap is the space between the last element of one character and the first element of the next character of a discrete bar code symbology.

The ***optical throw*** is the closest distance at which a scanner can read a bar code. When using contact scanners, this range will typically be from .0 to .02 of an inch. With non-contact scanners, optical throw can range up to a couple of feet.

Resolution is the narrowest dimension of a bar or space in a symbol that a scanner is able to read. This dimension is frequently mentioned as the "X" dimension, and is measured in mils.

Scan Rate refers to the number of times the bar code reader samples the barcode symbol before decoding it. For a contact wand, this is usually one. For a handheld, non-contact reader, the scanner could sample the bar code symbology anywhere from 30-200 times before decoding.

Self-checking is, at times, used synonymously with the term check-digit. A symbology is described as self-checking if a single printing defect will not cause a character to be transposed into another valid character in the same symbology.

Substitution Error Rate is the number of incorrect characters substituted in place of the correct character scanned. Typically, the problem lies in the print quality of the bar code. The use of check digits or characters will help in eliminating this problem.

The ***Wide-to-Narrow-Ratio*** is the number of narrow elements that make up a wide element. For example, if a bar code has a 3:1 ratio, the wide elements are three times the size of the narrow elements.

The ***X-Dimension*** is the nominal width of the narrow bars and spaces found in a bar code symbol. It is measured in mils (1/1000th of an inch).

Reference List of Bar Coding Software and Hardware Vendors

Printing Software and Wedge Reader

Tharo Systems has a terrific offer for any teacher. Tharo Systems will donate a free copy of their "EasyLabel" bar code printing software and provide you with a wedge reader for under $300.00 This, combined with Lotus 123, Excel, dBase or any other software you're using, will allow you to have a complete workable system at a very low cost. EasyLabel typically sells for $1,695-3,000 depending on the printer driver, so it's an incredible offer.

Contact: Tina Benko, Marketing Manager;
Tharo Systems, Inc.
2967 Nationwide Parkway, No.5
P.O. Box 798
Brunswick, Ohio 44212
(216) 273-4408

Bar Code Readers (These readers act as a wedge/second keyboard automatically. No special hardware or software setups are required, unless a RS-232 interface is used.)

Readers for the IBM PC or compatible computers, contact:

TPS Electronics
4047 Transport Street
Palo Alto, CA 94303
(800) 526-5920

SCANTECH
12981 Ramona Blvd.
Unit 1
Irwindale, CA 91706-3797
(818) 960-2999

American Microsystems
2190 A Regal Parkway
Euless, TX 76040
(800) 648-4452

TESCO, International
2165 Sunnydale Blvd.
Suite A
Clearwater, FL 34625
(813) 461-0500

Bar Code Readers

Readers for both IBM PC/Compatibles & Macintosh PC's, contact:

Worthington Data Solutions
417-A Ingalis Street
Santa Cruz, CA 95060
(800) 345-4220

International Technologies & Systems Corp.
655-K North Berry Street
Brea, CA 92621
(714) 990-1880

Percon Incorporated
1710 Willow Creek Circle
Eugene, OR 97402
(800) 873-7266

TimeKeeping Systems, Inc.
306-C, East 55th Street
Cleveland, Ohio 44103
(216) 361-9995

Bar Code Printing Software
For PC's operating under DOS contact:

Perrysberg Software Corp.
P.O. Box 488
Perrysberg, Ohio 43552
(419) 874-8502

Adex Corporation
1070 Ortega Way
Placentia, CA 92670
(714) 632-7000

FormMaker Software
111 Schillinger Rd. South
Mobile, AL
36608
(205) 633-3676

Bear Rock
6069 Enterprise Drive
Diamond Springs, CA
95619
(916) 622-4640

ZBAR
c/o Mr. Al Borges
263 Ashsale Ave
Syracuse, NY - 13206

Bar Code Printing Software
For running under Microsoft Windows 3.x contact:

Window Bar
Mayer Automation Group
P.O. Box 1328
Birmingham, AL 35201
(800) 289-6293

WBAR
Stellar Technologies
c/o Stu Gisburne
2510 Metro Blvd.
St. Louis, MO 63043

For Macintosh contact: (also contact TPS, see above address)

Bar Code Labeler
Videx, Inc
1105 NE Circle Blvd.
Corvallis, OR 97330-4285
(503) 758-0521

Data Capture Institute
30 Tremont Street
P.O. Box 1625
Duxbury, MA 02331
(617) 934-7585

Trade Publications to Keep You in the Know (they are free monthly magazines) contact:

Automatic I.D. News
7500 Old Oak Blvd.
Cleveland, Ohio 44130
(216) 891-2699

ID Systems Magazine
Helmers Publishing, Inc.
174 Concord St., P.O. Box 874
Peterborough, NH 03458-0874
(603) 924-9631

Handouts and Examples

The following ten pages include graphics that can be duplicated and used as handouts or overheads.

Graphic #1 *Auto ID is Keyless Data Entry*
Introduces the seven most prevalent forms of automatic identification.

Graphic #2 *There is No "Best" Auto ID Technology*
Some strengths of bar codes.

Graphic #3 *How Bar Code Scanners Work*
Schematic of a flatbed scanner prevalent in supermarkets.

Graphic #4 *Discrete vs. Continuous Codes*
Categorizes five prevalent bar code symbologies into discrete or continuous codes.

Graphic #5 *Mag Stripe Overview*
Provides an overview of magnetic stripe technology.

Graphic #6 *Radio Frequency Indentification (RFID)*
Provides an overview of RFID technology.

Graphic #7 *Various Types of RFID*
Categorizes RFID as passive or active and gives capabilities of each.

Graphic #8 *Keyboard Interface Driver "Wedge"*
Example of class menu sheet. - referenced on page 15 of this module

Graphic #9 *New York Times Article* (2 pages)
The future of bar coding, two dimensional symbologies (PDF 417) - referenced on page 14 of this module. Reprinted with Permission.

HAPPY BAR CODING!!

Auto ID is Keyless Data Entry

Do NOT use the keyboard ...

instead use:

- Bar Code
- Magnetic Stripe
- Radio Frequency Identification (RFID)
- Optical Character Recognition (OCR)
- Voice Recognition
- Machine Vision
- Smart Cards

There is No "Best" Auto ID Technology

Each has its own strengths.

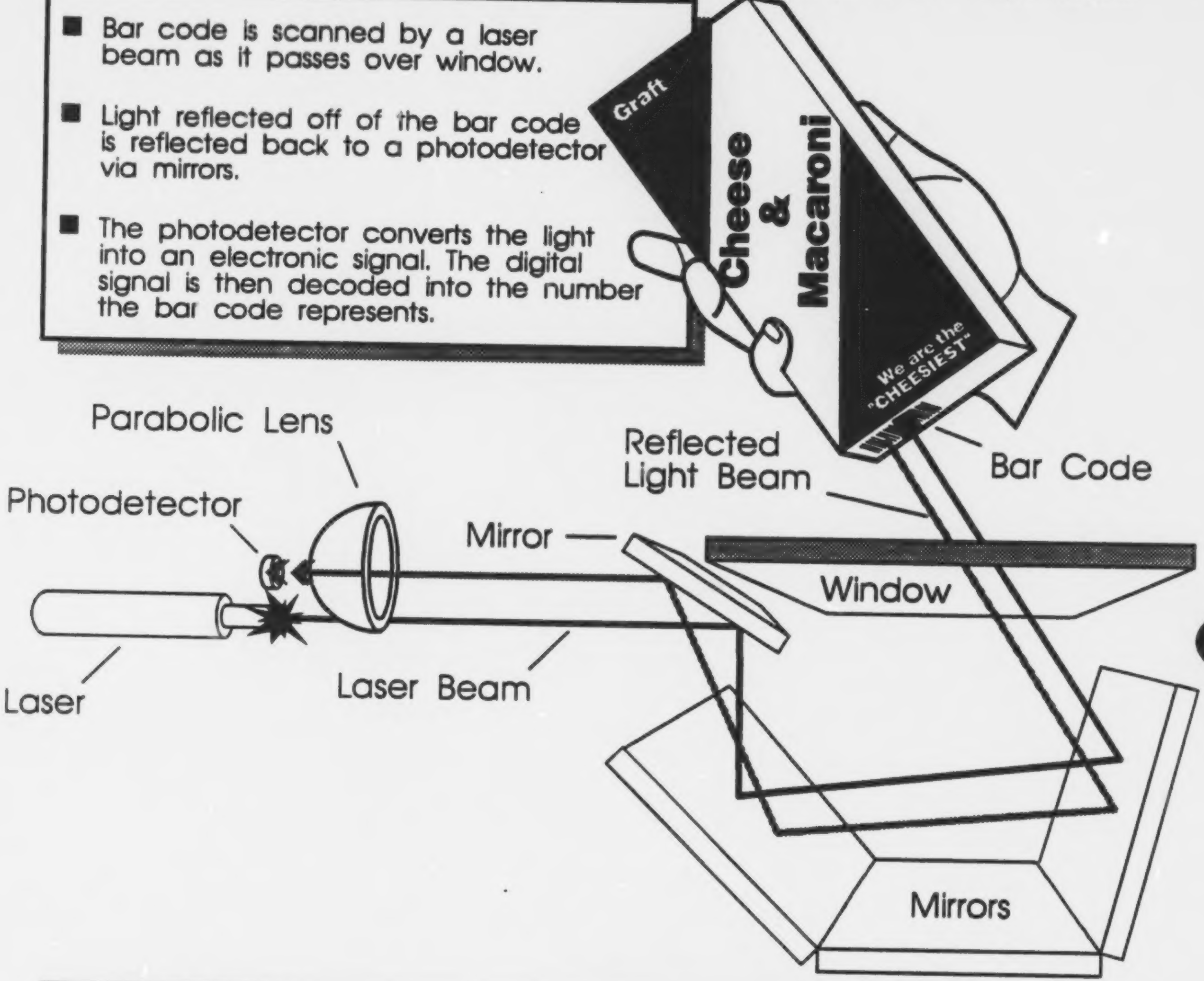
Some strengths of bar codes are:

- They are inexpensive and perform well.
- They make use of a variety of printing techniques.
- They provide inexpensive labeling.
- They offer accurate and fast data entry.
- They are relatively easy to teach and learn.

How Bar Code Scanners* Work

* Schematic represents flatbed scanner prevalent in supermarkets.

- Bar code is scanned by a laser beam as it passes over window.
- Light reflected off of the bar code is reflected back to a photodetector via mirrors.
- The photodetector converts the light into an electronic signal. The digital signal is then decoded into the number the bar code represents.


Graft
Cheese & Macaroni
We are the "CHEESIEST"
Parabolic Lens
Reflected Light Beam
Bar Code
Photodetector
Mirror
Window
Laser
Laser Beam
Mirrors

12345 67890

Universal Product Code (UPC):

- Black and white bars represent only numbers
- First five (5) numbers identify the manufacturer
- Second five (5) numbers identify the product

Benefits of the Barcodes:

- Excellent inventory tracking
- Easy determination of product turnover rates
- Simple price updates

Discrete vs. Continuous Codes

- In discrete codes, each character is separated from the adjacent character by a space called an intercharacter gap. Each character starts and ends with a bar.

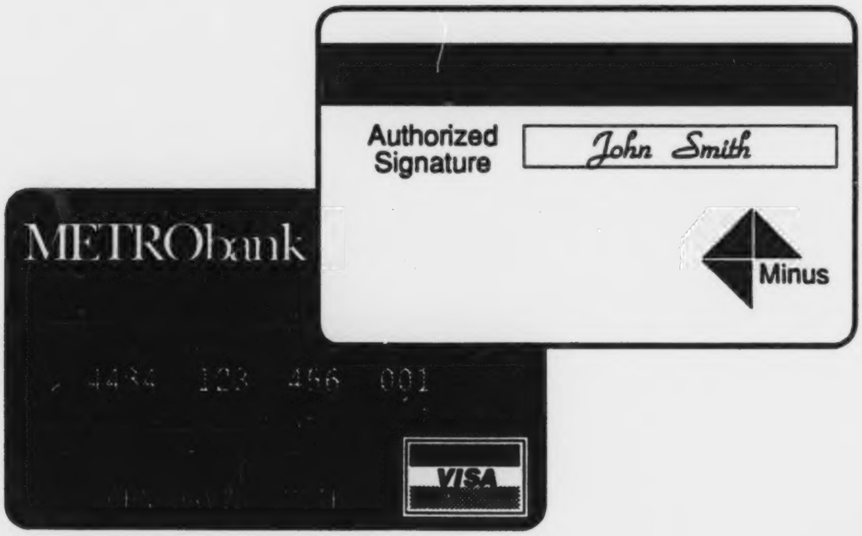
- Discrete bar codes can be printed on a wider variety of printers.

- Continuous codes have no intercharacter gap. Each character starts with a bar and ends with a space.

Symbology	Discrete	Continuous
Code 39	■	
Interleaved 2 of 5		■
UPC		■
Code 128		■
Codabar	■	

Magnetic Stripe Overview

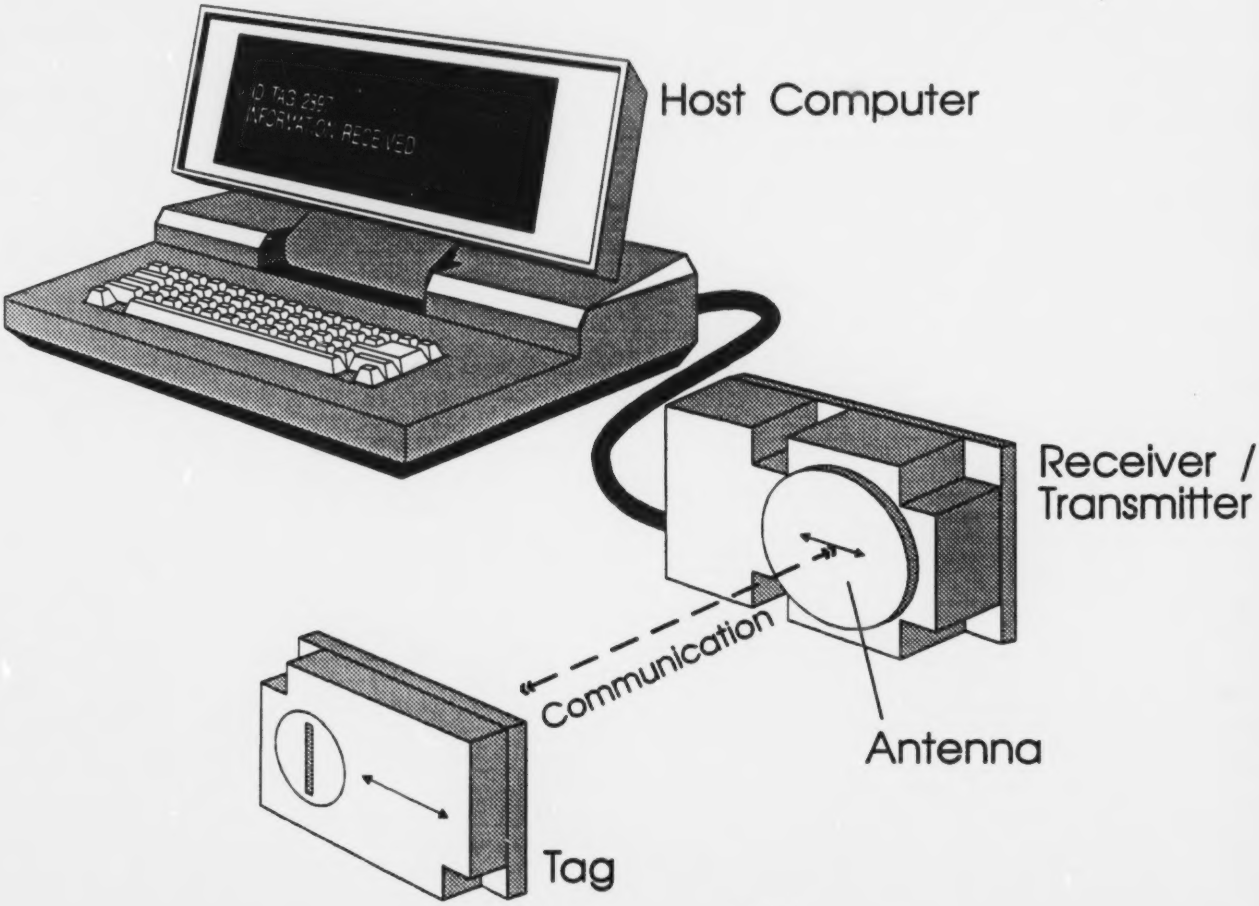
- Technology has been around for over 20 years.
- Over 1 billion credit cards in the U.S alone.
- Mag stripe credit cards are used to purchase half a trillion dollars in goods annually.
- Mag stripe cards are used for ID badges, door lock access cards, mass transit and turnpike tickets, airline tickets, vending machine cards, factory floor collection cards, etc.
- Requires contact with a reader.
- Mag stripe credit cards are not readable by humans.
- The future promises continued growth with denser magnetic stripes.


Authorized Signature
John Smith
Minus
METRObank
4434 123 456 001
VISA

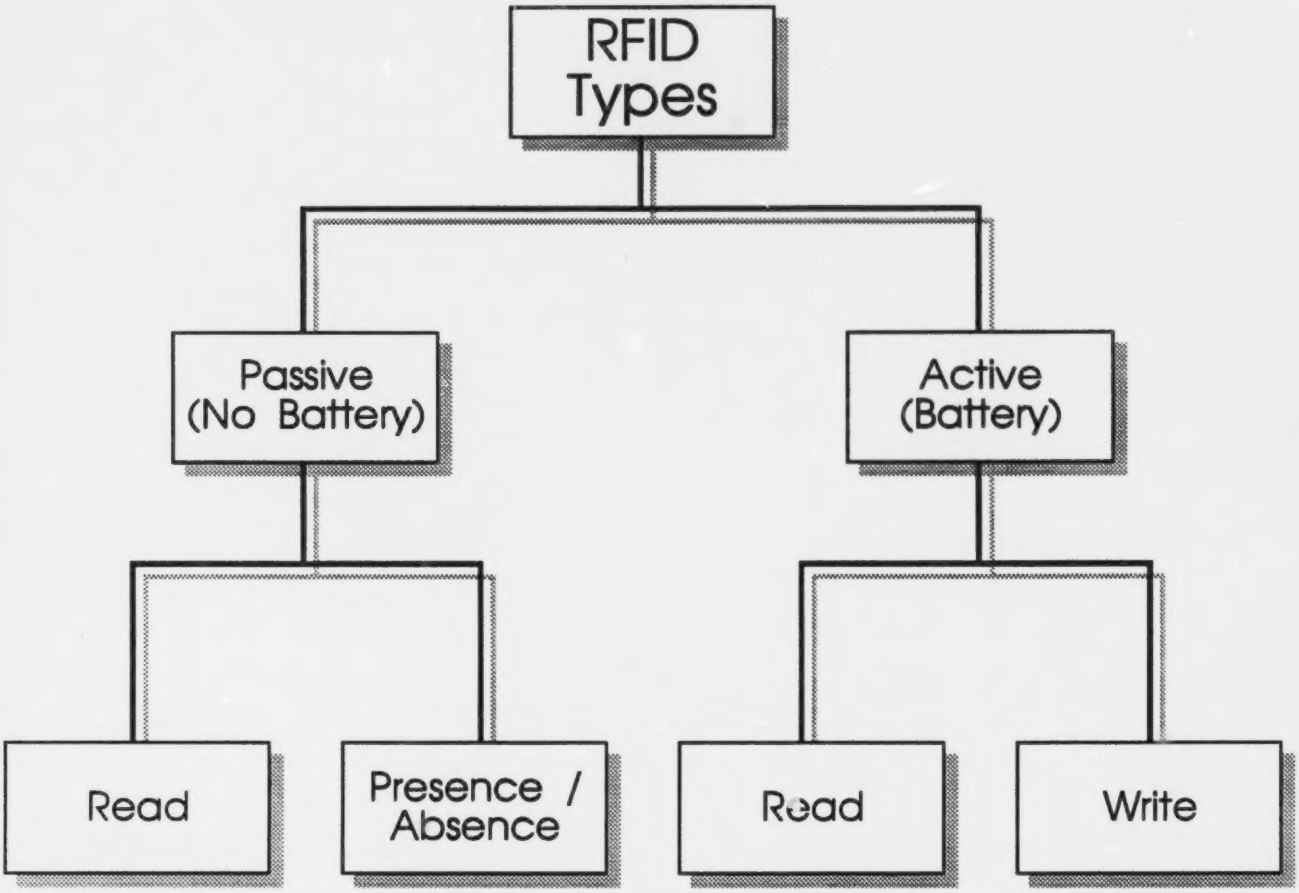
Radio Frequency Identification (RFID)

Attributes:

- Omni-directional
- No line-of-sight requirement (non-optical system)
- Non contact
- No visual backup
- Very durable, life in excess of 10 years
- Can be painted, dipped in acid, etc.


ID TAG 2397
INFORMATION RECEIVED
Host Computer
Receiver / Transmitter
Communication
Antenna
Tag

Various Types of RFID



- RFID Types
  - Passive (No Battery)
    - Read
    - Presence / Absence
  - Active (Battery)
    - Read
    - Write

KEYBOARD INTERFACE DRIVER "WEDGE"

PC Control Characters

F1 F2 F3 F4 F5

F6 F7 F8 F9 F10

RIGHT UP HOME INS PGUP

LEFT DOWN END DEL PGDN

---

1 2 3 4 5

6 7 8 9 0

ENTER ESC

TESCO

TESCO INTERNATIONAL INC.

2907 S.R. 590 SUITE 10, CLEARWATER, FL 34619 • PHONE: (813) 796-0300 • FAX: (813) 797-8757

The New York Times

WEDNESDAY, APRIL 24, 1991

For Bar Codes, an Added Dimension

By BARNABY J. FEDER

After years of playing an important bit part in the information revolution, the bar code is being groomed for a more demanding role. Several companies that make scanning and printing equipment have designed new codes, the most sophisticated of which can actually work as if they were miniature printouts from computer data files.

The new codes are expected to replace lengthy typewritten shipping documents, allow manufacturers to individually label small items like microchips, and help prevent the mishandling of hazardous waste, among other applications.

Most of the ubiquitous black and white stripes printed in the corner of newspapers and on the sides of cereal boxes represent short sequences of numbers, letters, or both. Somewhat like figures on license plates, each bar code is really a label for files of information that are stored elsewhere in a computer. When a laser at the checkout counter scans the bar code on a box of grits, for instance, the store's computer instantly tells the cash register the price and how to describe it on the receipt.

The new bar codes allow lines of code to be stacked up, storing information in two dimensions instead of in one line. Symbol Technologies Inc., which is based in Bohemia, L.I., and is the nation's largest bar-code equipment supplier, has developed the most sophisticated of the new so-called two-dimensional, or 2D, codes. The code can pack several hundred characters into a square inch of space, serving, in essence, as a portable data file on paper instead of a floppy disk.

"You could call it a non-technical form of electronic data interchange," said Robert Moore, director of technical publications for Automatic Identification Manufacturers Inc., a trade group based in Pittsburgh.

Backers of the 2D codes say they could substitute for papers about a shipment. Instead of typing out lists of the contents of a shipment and its routing, a small textile company could print the information in bar code form and fax it to shippers and retailers, who would scan it to put the data into their computer files.

The same bar symbol would be attached to the shipment. From then on, all parties involved in the stream of trade would have a much easier time tracking the goods, leading to fewer distribution errors, better scheduling of trucks and warehouse space, quicker recording of transfers and smoother reordering.

The new codes might also help manufacturers track production of complex machines, like tractors, without stuffing a plant with computer terminals and support equipment. A 2D bar symbol could be scanned to tell workers, or a robot, where a part came from, what needed to be done, where it had to go next, and when. An updated symbol reflecting completion of the work could be printed out for less than half a cent and attached to the part before sending it on. The complete record could be put in the plant's main computer system at the end of the day.

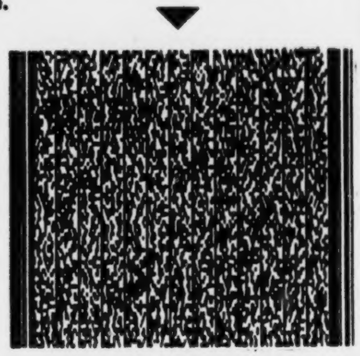
"It could save a lot of computer power and bring more affordable data capture to the factory floor," said Donald Wauchope, a consultant based in Rosemount, Ill., who has been working on prototype 2D systems with several manufacturers for the Austin Company of Cleveland, an engineering consulting firm.

Two-dimensional codes might also be a useful way to keep production records and maintenance schedules with military equipment that is suddenly sent to remote areas beyond the reach of the Defense Department's computer networks. The Energy Department is considering using them to attach detailed handling instructions and other information to hazardous waste shipments. Two-dimensional bar code labels might also be used to post repair records on leased equipment. And direct mailers might use them to build new information files limited to people who respond to their junk mail.

To be sure, standard linear bar codes continue to find new applications. American businesses and institutions spent $2.1 billion on bar code equipment, supplies, and services last year, according to the Venture Development Corporation, a market research firm based in Natick, Mass. That figure is expected to double by 1995, even without a contribution from 2D codes.

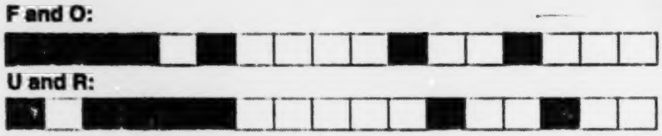
The Gettysburg Bar Code

The Gettysburg Address expressed as a two-dimensional bar code, shown on the right at actual size.



Below are two code "words" containing the first four letters of Lincoln's speech. Each "word" is 17 modules long, containing four bars (in black) and four spaces (in white). The code is read from left to right, in rows from top to bottom.

A standard one-dimensional bar code representation of the same speech would be 24 feet wide.



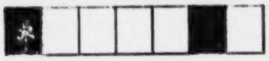
Source: Symbol Technologies

The New York Times

That Thing on the Side of the Cereal Box

0 354653 16

This Universal Product Code holds information in a pattern of bars and spaces. Data are contained in a series of "words" like the one below, placed end to end and read horizontally. The height of the bars has no connection to the data content.



◀ **A Universal Product Code "word"**

A UPC code "word" consists of two bars (in black) and two spaces (in white), within seven modules. No bar can exceed three modules. The distinct pattern formed by each "word" corresponds to a number from zero to nine. For example, the "word" above corresponds to the number three in the bar code shown on the upper left.

Source: Symbol Technologies

The New York Times

20 Languages

Over time, more than 20 linear bar code languages have developed, each with its own specifications for how many bars and spaces make up a character, how characters are to be arranged, whether the characters can be letters as well as numbers, and so forth. The most widely used is the UPC, or Universal Product Code, that consumers see in grocery stores.

The problem, though, is that some bar code users want to put more information on products than linear codes can handle without stretching to unwieldy lengths. Hospitals, for example, want to put more medical information on patient identification bracelets than scanners can read before running into problems with the curvature of the bracelet. Standard codes also take up too much space to be useful for quality control on microchips or single-pill packaging in the pharmaceutical industry.

The first two-dimensional codes invented in the late 1980's were essentially stacked versions of existing codes. The most promising of these, like the Intermec Corporation's Code 49 and Laserlight System Inc.'s Code 16K, are still undergoing independent testing.

"Neither has taken off," said Roger Palmer, head of research at Intermec, a Lynnwood, Wash., company that last week agreed to be acquired by Litton Industries. "It typically takes five years for a code to gain critical mass." He said that Code 49 could squeeze 88 numbers or 49 letters into a single symbol, more than double the practical limit for linear codes.

These first 2D codes do well at cramming modest amounts of information into tight spaces but fall short as portable files, so Symbol Technologies decided to start with a clean slate in designing its 2D format. The company began by reviewing theoretical research on code and information theory. The code it created, known as PDF 417, began circulating among user groups and suppliers last year and was submitted to the Automatic Identification Manufacturers' standards committee last month.

New Scanners Awaited

Symbol Technologies hopes that the committee will recommend standards based on the code by the end of the year. PDF 417 was designed to be printed by existing printers and is readable with current scanners. But as a practical matter, it is unlikely to catch on until Symbol Technologies and others produce a new generation of inexpensive scanners that can automatically move up and down the rows of code, a process that now requires a steady hand. The first such scanners are expected next year.

PDF 417 is constructed from data units called "words," each of which is 17 modules long. Bars are made from filling in up to six consecutive modules and each unit has four separate bars and four spaces. There are 10,480 different possible words, far more than in standard codes that work with data units made up of fewer modules.

In a particular application, just 929 words are chosen. Each word has three separate forms, as if it were in English, French and German, making a total of 2,787 bar-and-space variations selected for maximum distinguishability from each other. Each row of the symbol is in a different coding language, to help the scanner, and the computer driving it, keep track of which line is being read.

The true power of PDF 417, however, is that each of the 929 words has 15 different modes. It is as if the code sees each word as a typewriter key that not only has upper case and lower case but 13 other possible positions as well. The code tells the scanner which mode or level of meaning a series of words is in and and when the symbol is switching to another.

In the proposed standard being considered by the manufacturers' committee, the first two modes are reserved for what Symbol Technologies hopes will be universally accepted meanings in digital and ASCII formats, just as letters always appear at an agreed spot in the standard Qwerty typewriter keyboard. ASCII is a common computer code for representing text. Users would be free to assign whatever meaning they want for each position in the other 13 modes, including Kanji characters for Japanese users.

No one is sure yet how big a market there is for such sophisticated bar codes, but executives at Symbol Technologies see it as a series of niches, many of which remain to be discovered. "It's going to get used in a lot of surprising ways," said James E. Bagley, the company's director of industry marketing.

© 1991 by The New York Times Company. Reprinted by permission.

symbol®

SYMBOL TECHNOLOGIES, INC. 116 Wilbur Place, Bohemia, NY 11716 • 516 563-2400 • TLX:6711519 • FAX 516 563-2831

Module 5:
AN INTERDISCIPLINARY MODULE ON BARCODING

LANGUAGE ARTS DESIGN BRIEFS

by

James Green
Professor of Secondary Education
Department of Secondary, Higher, and Foundations of Education
Ball State University

Abstract

This unit presents sample projects, called Design Briefs, for langauge arts teachers who make use of the material presented in the "Background for Teachers" section of this module. These projects were designed to be used in concert with projects in Mathematics Design Briefs, Science Design Briefs, and Technology Design Briefs.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

The Role of Language Arts in the Interdisciplinary Tech Prep Unit

The Tech Prep curriculum, in its best form, blends all the major disciplines into projects that derive from real world settings. As a consequence, knowledge and skills from mathematics, language arts, science, or technology are really parts of a system rather than mere pieces of a puzzle. The distinction is important. In a system, if any part is missing or does not function properly, the system fails. However, in an elaborate puzzle, if only one piece is missing the puzzle will be incomplete, but it will probably hold together.

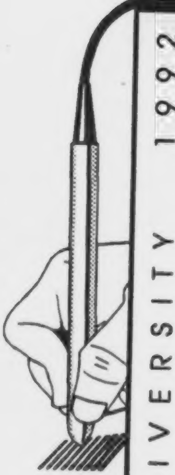
The role of language arts in an interdisciplinary Tech Prep unit is exemplified in this unit on bar coding. Staff training and customer relations are irreplaceable elements in the total "system" of applying bar coding technology. Both are intricate communications problems that involve high levels of proficiency in oral and written discourse, as well as the imaginative use of visual media. Planning the incorporation of these skills into the interdisciplinary unit places the language arts instructor in an indispensable role among the team of teachers.

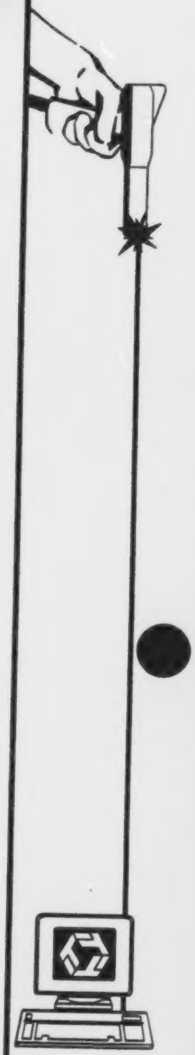
DESIGN BRIEF

BAR CODING

■LANGUAGE ARTS■

TECH PREP - PURDUE UNIVERSITY 1992





CODE 39

Design Brief I:
Technical Writing - Documentation for Computer Software

Problem:
You and three of your co-workers are employees of a large retailing business that is in the process of converting its inventory and pricing systems to bar coding. Your company has used its own computer software engineers to develop its own computer software for bar coding the inventory items. Although the software is very "user friendly," it will still need to have a manual for the users. Your assignment is to write the manual for the computer software (see attached computer software titled "ZBAR") that will both instruct the beginning user and serve as a technical reference for experienced users. To complete your assignment you will need to become expert at using the software yourselves, then explain in writing and with graphics that depict computer screen displays how to use the software step by step. Your technical manual will need to be composed with word processing and desktop publishing software.

Proficiencies:

Listed below are the English/language arts proficiencies (grades 9-12) from the Indiana Department of Education English/Language Arts Proficiency Guide. Each proficiency is considered from the extent to which it is addressed by the design brief on "Technical Writing."

1. Exhibit a positive attitude toward language and learning through . . . participating in activities related to speech and debate, drama, journalism; submitting works for publication; entering literary, speech, and writing contests.

   No Emphasis

2A. Use developmentally appropriate materials to select and apply effective strategies for reading, including . . . reading from different points of view; making and defending judgements about quality and content, including information generated through technology.

   Strong Emphasis

2B. Comprehend developmentally appropriate materials, including . . . broad variety of literature, magazines and newspapers written for a general adult audience; directions on forms and products; technical procedures, as in computer use; common legal agreements.

   Strong Emphasis

3A. Select and use developmentally appropriate strategies for writing, including . . . choosing methods of organization appropriate to audiences and purpose; revising writing for clarity, coherence, economy, and style; preparing final drafts that adhere to accepted conventions.

   Strong Emphasis

3B. Write for different purposes and audiences using a variety of forms, including . . . notes and messages; syntheses of information from a variety of sources; completion of complex forms; complex directions; persuasive letters.

   Strong Emphasis

4. Use prior knowledge and subject area information to make critical judgements, including . . . distinguishing between objective and subjective presentations of information and events; understanding how language is used to influence; identifying bias and its implications in mass media, understanding implied meanings.

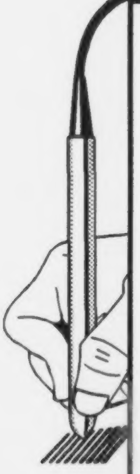
Limited Emphasis

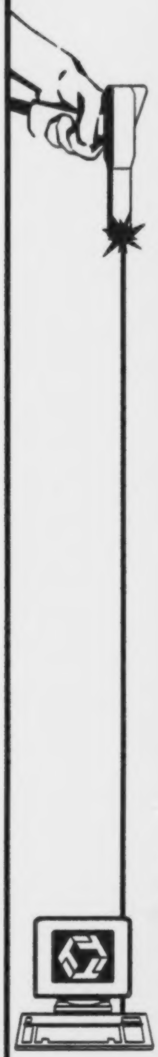
5. Communicate orally and in writing with all ages of people by . . . working collaboratively to generate ideas and solve problems; speaking effectively to an audience; expressing and defending one's own ideas; participating in interviews.

Strong Emphasis (writing communication)
Limited Emphasis (oral communication)

6. Recognize the inter-relatedness of language, literature, and culture by reading some of the recognized masterpieces and authors; explaining how historical events are reflected in works of a given period; understanding how contemporary writing reflects past literary traditions; developing criteria for judging the quality of literary works.

No emphasis





Design Brief II: Multimedia Presentation

Problem:

You and three of your co-workers are employees of a large retailing business that is in the process of converting its inventory and pricing systems to bar coding. Your company has decided to design and produce its own program for training employees in the new operations. Your assignment will be to develop and present a multimedia presentation designed to instruct the employees in all phases of the bar coding process. First, you will need to become familiar with the process and related technology yourself. You then will need to plan what kinds of knowledge and skills the different kinds of employees will need to have. Next, you will outline and script the training presentations, complete with diagrams and examples. You will plan to present your training programs using video recordings of demonstrations, overhead transparency (or video floppy disk) projections, and handouts with examples. Finally, you will need to compile all your training information into a self-contained training manual, so that when new employees begin after the initial training sessions they will have access to your training program through your training manual.

Proficiencies:

Listed below are the English/language arts proficiencies (grades 9-12) from the Indiana Department of Education English/Language Arts Proficiency Guide. Each proficiency is considered from the extent to which it is addressed by the design brief on "Multimedia Presentations."

1. Exhibit a positive attitude toward language and learning through . . . participating in activities related to speech and debate, drama, journalism; submitting works for publication; entering literary, speech, and writing contests.

   No Emphasis

2A. Use developmentally appropriate materials to select and apply effective strategies for reading, including . . . reading from different points of view; making and defending judgements about quality and content, including information generated through technology.

   Strong Emphasis

2B. Comprehend developmentally appropriate materials, including . . . broad variety of literature, magazines and newspapers written for a general adult audience; directions on forms and products; technical procedures, as in computer use; common legal agreements.

   Strong Emphasis

3A. Select and use developmentally appropriate strategies for writing, including . . . choosing methods of organization appropriate to audiences and purpose; revising writing for clarity, coherence, economy, and style; preparing final drafts that adhere to accepted conventions.

   Strong Emphasis

3B. Write for different purposes and audiences using a variety of forms, including . . . notes and messages; syntheses of information from a variety of sources; completion of complex forms; complex directions; persuasive letters.

   Strong Emphasis

4. Use prior knowledge and subject area information to make critical judgements, including . . . distinguishing between objective and subjective presentations of information and events; understanding how language is used to influence; identifying bias and its implications in mass media, understanding implied meanings.

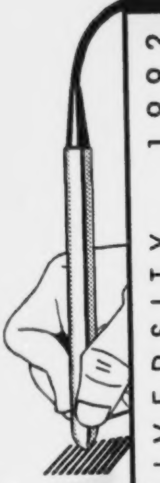
Limited Emphasis

5. Communicate orally and in writing with all ages of people by . . . working collaboratively to generate ideas and solve problems; speaking effectively to an audience; expressing and defending one's own ideas; participating in interviews.

Strong Emphasis

6. Recognize the inter-relatedness of language, literature, and culture by reading some of the recognized masterpieces and authors; explaining how historical events are reflected in works of a given period; understanding how contemporary writing reflects past literary traditions; developing criteria for judging the quality of literary works.

No emphasis



Design Brief III: Sales Presentation

Problem:
You and three of your co-workers are sales representatives of a company that distributes bar coding technology to businesses or other clients. You have successfully persuaded the CEO of a large retailing business (that does not presently use bar coding) to listen to what you have to say about your product. The CEO is skeptical because her business has been very profitable without the new inventory and pricing systems your firm is selling. But, she is willing to give you and your associates "thirty minutes." Your assignment is to prepare your sales presentation. You will need to convince your customer that the initial investment in the computer systems, scanners, and employee training, not to mention the equipment maintenance and periodic upgrades, will improve her profit margin (the "bottom line"). First, you will need to become an expert in the applications of bar coding to the retailing industry. Next, you will need to outline your presentation so that you are certain to cover all the important points in a persuasive manner. Your presentation should use video recordings, slides, and charts demonstrating how the system operates.

CODE 39

Proficiencies:

Listed below are the English/language arts proficiencies (grades 9-12) from the Indiana Department of Education English/Language Arts Proficiency Guide. Each proficiency is considered from the extent to which it is addressed by the design brief on "Sales Presentation."

1. Exhibit a positive attitude toward language and learning through . . . participating in activities related to speech and debate, drama, journalism; submitting works for publication; entering literary, speech, and writing contests.

   No Emphasis

2A. Use developmentally appropriate materials to select and apply effective strategies for reading, including . . . reading from different points of view; making and defending judgements about quality and content, including information generated through technology.

   Strong Emphasis

2B. Comprehend developmentally appropriate materials, including . . . broad variety of literature, magazines and newspapers written for a general adult audience; directions on forms and products; technical procedures, as in computer use; common legal agreements.

   Strong Emphasis

3A. Select and use developmentally appropriate strategies for writing, including . . . choosing methods of organization appropriate to audiences and purpose; revising writing for clarity, coherence, economy, and style; preparing final drafts that adhere to accepted conventions.

   Strong Emphasis

3B. Write for different purposes and audiences using a variety of forms, including . . . notes and messages; syntheses of information from a variety of sources; completion of complex forms; complex directions; persuasive letters.

   Strong Emphasis

4. Use prior knowledge and subject area information to make critical judgements, including . . . distinguishing between objective and subjective presentations of information and events; understanding how language is used to influence; identifying bias and its implications in mass media, understanding implied meanings.

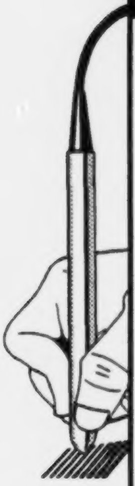
Strong Emphasis

5. Communicate orally and in writing with all ages of people by . . . working collaboratively to generate ideas and solve problems; speaking effectively to an audience; expressing and defending one's own ideas; participating in interviews.

Strong Emphasis

6. Recognize the inter-relatedness of language, literature, and culture by reading some of the recognized masterpieces and authors; explaining how historical events are reflected in works of a given period; understanding how contemporary writing reflects past literary traditions; developing criteria for judging the quality of literary works.

No emphasis



Design Brief IV: Creative Writing

Problem:

The imaginative mind in science fiction oftentimes is the conscience of technology. Tales that have forewarned us of ecological disaster, nuclear holocaust, and subtle enslavement of individuals are proof that literary artists have contributed much to the sensible and ethical uses of technology. Writers have also foreseen and written about many applications of technology that did not even dawn on the inventors originally. Your assignment is to write either a short story or a play in which "bar coding" plays an instrumental role in the development of the plot. Your work of fiction should leave the reader with impressions on the implications of bar coding that go beyond the mere technical applications. Before beginning, you will find it helpful to read several science fiction stories or screen plays that use bizarre applications of emerging technologies as the central element of their plots.

CODE 39

Proficiencies:

Listed below are the English/language arts proficiencies (grades 9-12) from the Indiana Department of Education English/Language Arts Proficiency Guide. Each proficiency is considered from the extent to which it is addressed by the design brief on "Creative Writing."

1. Exhibit a positive attitude toward language and learning through . . . participating in activities related to speech and debate, drama, journalism; submitting works for publication; entering literary, speech, and writing contests.

   Possible Emphasis

2A. Use developmentally appropriate materials to select and apply effective strategies for reading, including . . . reading from different points of view; making and defending judgements about quality and content, including information generated through technology.

   Strong Emphasis

2B. Comprehend developmentally appropriate materials, including . . . broad variety of literature, magazines and newspapers written for a general adult audience; directions on forms and products; technical procedures, as in computer use; common legal agreements.

   Slight Emphasis

3A. Select and use developmentally appropriate strategies for writing, including . . . choosing methods of organization appropriate to audiences and purpose; revising writing for clarity, coherence, economy, and style; preparing final drafts that adhere to accepted conventions.

   Strong Emphasis

3B. Write for different purposes and audiences using a variety of forms, including . . . notes and messages; syntheses of information from a variety of sources; completion of complex forms; complex directions; persuasive letters.

   Slight Emphasis

4. Use prior knowledge and subject area information to make critical judgements, including . . . distinguishing between objective and subjective presentations of information and events; understanding how language is used to influence; identifying bias and its implications in mass media, understanding implied meanings.

Slight Emphasis

5. Communicate orally and in writing with all ages of people by . . . working collaboratively to generate ideas and solve problems; speaking effectively to an audience; expressing and defending one's own ideas; participating in interviews.

No Emphasis

6. Recognize the inter-relatedness of language, literature, and culture by reading some of the recognized masterpieces and authors; explaining how historical events are reflected in works of a given period; understanding how contemporary writing reflects past literary traditions; developing criteria for judging the quality of literary works.

Strong emphasis

Module 5:
AN INTERDISCIPLINARY MODULE ON BARCODING

MATHEMATICS DESIGN BRIEFS

by

Peter Kloosterman
Associate Professor of Education
School of Education
Indiana University

Abstract

This unit presents sample projects, called Design Briefs, for mathematics teachers who make use of the material presented in the "Background for Teachers" section of this module. These projects were designed to be used in concert with projects in Language Arts Design Briefs, Science Design Briefs, and Technology Design Briefs.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

The Role of Mathematics in the Interdisciplinary Tech Prep Unit

The primary purpose of the lessons that follow is to give the Tech Prep mathematics teacher some examples of how mathematics is being used in today's technology, in particular bar code technology. There are several different mathematical ideas that are utilized in the lessons that follow as well as some methodological suggestions which are in keeping with the philosophy of Tech Prep and the National Council of Teachers of Mathematics' *Standards*. For a more complete description of teaching mathematics in a Tech Prep environment, refer to the Introductory Comments that accompany the other mathematics units in this curriculum package.

The UPC-A bar code technology utilizes several different mathematical concepts. The actual encoding of each number into bars is based on a binary number representation involving seven digits. Each twelve-digit code number that is recorded on the product contains a check number that is based on modular arithmetic (mod 10) and also relies on the ability to solve linear equations. One of the lessons utilizes the fact that part of the bar code identifies the manufacturer and suggests problems involving the counting principle that challenge the student to determine the number of companies that can be encoded. Other mathematical topics that can be introduced within the context of bar coding include measurement, percentage, and data collection and analysis.

Key components of the philosophy of Tech Prep include cooperative learning, applications based instruction, problem solving,and attention to different learning styles. The lessons that follow contain numerous opportunities for cooperative learning--in fact some would not be very effective without the use of group effort. Each lesson carries with it an attempt to show how mathematics can be applied to identification technology. In terms of problem solving, most of the activities are intended to challenge the student to discover the solution to a new situation--a true problem. And some of the activities are of an open-ended nature which should accommodate students with different learning styles.

It is hoped that these lessons will provide examples of how mathematics can be used in an activity-oriented manner and that Tech Prep teachers will use them as a springboard for creating their own lessons. In particular, bar coding might spark an interest in the mathematics of coding in general. The use of modular arithmetic might encourage the development of problems using clock or calendar arithmetic. The lessons that utilize the counting principle might lead to a host of activities that involve counting, permutations, or combinations. Explore the world of mathematics based on what works best for your students!

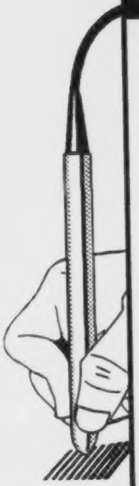
UPC-A BACKGROUND FOR MATHEMATICS LESSONS

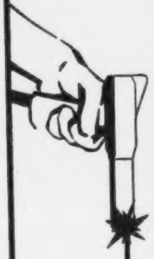
Universal Product Code (UPC) information is found on pages 12-13 of Module 5, Background for Teachers.

BAR CODING

▪ MATHEMATICS ▪

TECH PREP - PURDUE UNIVERSITY 1992





Design Brief I: Cracking a Bar Code

Problem: To unlock one of the mathematical keys to aid in the understanding of the UPC-A bar coding system.

Mathematical Competencies Used: The use of modular arithmetic (modulo 10). Modular arithmetic deals with numbers that are congruent based on their remainder with respect to a particular divisor. For example, $7 \equiv 13 \pmod 3$ because 7 and 13 divided by 3 both have a remainder of 1. Thus, $18 \equiv 3 \pmod 5$ and $26 \equiv 4 \pmod{11}$.

Situation: Modular arithmetic is used to provide a numerical check to the UPC-A system. In order for the UPC-A number to be valid, the twelve numbers in the bar code must satisfy the following condition: $3a_1 + a_2 + 3a_3 + a_4 + 3a_5 + a_6 + 3a_7 + a_8 + 3a_9 + a_{10} + 3a_{11} + a_{12} \equiv 0 \pmod{10}$. Another way of stating the above congruence relationship is to say that 3 times the sum of the digits in the odd positions plus the sum of the digits in the even positions is congruent to 0 (mod 10). Have students bring several UPC-A bar codes with them to class (have plenty of extras for those students who forget theirs). Note: for this exercise not all UPC-A items will be appropriate to use since not all of them have the 12th digit listed. Have groups of students, after they are comfortable with the concept of modular arithmetic, check the validity of several bar codes. Then have students make their own bar code by randomly generating numbers from 0 to 9 until they have the 12 digits needed. Have them check the validity of the number that they have created. If it is not a valid number, what could be done to change the number to make it valid?

CODE 39

Discussion: (sample) Check the validity of the UPC-A number 065961100602. $3(0 + 5 + 6 + 1 + 0 + 0) + (6 + 9 + 1 + 0 + 6 + 2) = 3(12) + (24) = 36 + 24 = 60 \equiv 0 \pmod{10}$. Therefore, it is a valid number. Check the validity of the UPC-A number 057627529316. $3(0 + 7 + 2 + 5 + 9 + 1) + (5 + 6 + 7 + 2 + 3 + 6) = 3(24) + (29) = 72 + 29 = 101 \equiv 1 \pmod{10}$. Therefore, it is not a valid number.

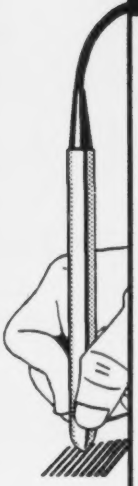
Homework: Assign students the task of finding three 12-digit UPC-A numbers and have them check their validity. Also, have them randomly choose 3 12-digit numbers and check their validity. Check the entire class results to find the percentage of valid UPC-A numbers in the class as a whole based on random selection.

DESIGN BRIEF

BAR CODING

▪ MATHEMATICS ▪

TECH PREP - PURDUE UNIVERSITY 1992



Design Brief II: Finding the Missing Check Number

Problem: To find the 12th digit (check #) on the UPC-A numbering system which is left off of many products.

Mathematical Competencies Used: Solving first degree equations within the framework of mod 10 arithmetic. Using cooperative learning (working in pairs) and making connections between two methods for finding an unknown number.

Situation: The 12th number of the UPC-A system is the check number. It is the one that makes the whole 12-digit scheme fit the condition that 3(sum of the digits in the oositions) + (sum of the digits in the even positions) ≡ 0 (mod 10). All of the other digits are used to identify the manufacturer and product while the 12th digit is designed to simply "make up the difference" in mod 10. However, while the check digit is always bar coded in the UPC-A system, it is not always written on the product in numerical form. The task of the students will be to find the missing check digit. Have students work in groups of two and give them a bar code that has the check digit missing. One student should be instructed to find the 12th digit mathematically, while the other student "reads" the widths of the bars and spaces of the bar code and looks up the number on the right hand code chart (see table 1--UPC Encoding Scheme). If the two reach agreement on their findings, they can be fairly sure that they are correct. If their numbers do not agree, have them switch tasks and try to find the check digit using the alternative approach. Based on the learning styles of the students some may find it easier to take on one role or the other in the pair. However, try to make sure that everyone is exposed to both methods of discovering the check digit.

Discussion: Use the bar code number 06592143210. The equation for solving to find the check number would be: $3(0 + 5 + 2 + 4 + 2 + 0) + (6 + 9 + 1 + 3 + 1 + C) \equiv 0 \pmod{10}$. Then simplify to $3(13) + (20 + C) \equiv 0 \pmod{10}$. By substitution, $39 + 20 + C \equiv 0 \pmod{10}$ and finally, $59 + C \equiv 0 \pmod{10}$. Thus, C would have to be 1 (of the numbers from 0-9) for the left hand side of the congruence statement to be 60, which is congruent to 0 (mod 10).

Homework: Have students find three bar coded items that do not have the check number printed on it. Have them find the number by solving an equation using mod 10 and by finding the bar coding for the twelfth number and translating it into the appropriate number from the right hand code chart. Make sure that the two numbers check.

CODE 39

DESIGN BRIEF BAR CODING

▪ MATHEMATICS ▪

TECH PREP - PURDUE UNIVERSITY 1992

Design Brief III: Cracking Another Bar Code

Problem: To discover the mathematics involved in the IBM bar coding system.

Mathematical Competencies Used: The use of modular arithmetic (modulo 10), a permutation-based coding system, and equation solving skills.

Situation: The IBM code is a more complicated but also more error-proof coding system than the UPC-A system. It also includes a check number as its last digit. And like the UPC-A scheme, it uses mod 10 arithmetic to arrive at this number. However, instead of a simple system of multiplying all of the odd digits by three, adding them to the sum of all of the even digits, and setting that sum congruent to zero (mod 10), the IBM scheme utilizes a permutation for encoding. The congruence statement for a code with an even number of digits is $\sigma(a_1) + a_2 + \sigma(a_3) + a_4 + \ldots + \sigma(a_{n-1}) + a_n \equiv 0 \pmod{10}$, where σ maps numbers according to an encoding scheme and the alternate digits are unchanged. If the number of digits in the bar code is odd, σ is applied to the even numbered positions instead of the odd positions as shown above. For this lesson, let us use the permutation (0)(124875)(36)(9) which means that 0 → 0, 1 → 2, 2 → 4, 4 → 8, 8 → 7, 7 → 5, 5 → 1, 3 → 6, 6 → 3, and 9 → 9. As an example, take the IBM code number 8259436398. Since there are an even number of digits, σ functions on the digits in the odd positions. The resulting congruence statement would be 7 (8 maps into 7) + 2 (2 in an even position remains unchanged) + 1 (5 maps into 1) + 9 + 8 + 3 + 3 + 3 + 9 + 8 $\equiv$ 0. Since the sum of the left side is 50 which is congruent to zero (mod 10), the code is a valid one in the IBM system. Have students work in groups to come up with valid IBM codes of both an odd and an even number of digits. Then provide the groups with the code numbers 9776827468C and 320053461C and have them solve for the missing check digit.

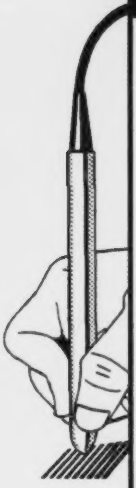
Discussion: As an example, check the validity of 345678921, which has an odd number of digits. The congruence statement will be $3 + 8 + 5 + 3 + 7 + 7 + 9 + 4 + 1 \equiv 0 \pmod{10}$. Since the sum of the left-hand side, 47, is not congruent to 0, the number 345678921 is not a valid IBM code number. For 9776827468C (an odd number of digits), the congruence statement would be $9 + 5 + 7 + 3 + 8 + 4 + 7 + 8 + 6 + 7 + C \equiv 0 \pmod{10}$. This simplifies to $64 + C \equiv 0$, which means $C = 6$. For 320053461C (an even number of digits), the congruence statement would be $6 + 2 + 0 + 0 + 1 + 3 + 8 + 6 + 2 + C \equiv 0 \pmod{10}$. This simplifies to $28 + C \equiv 0$, which means $C = 2$.

Homework: Have students create 3 valid IBM numbers and find the check digits on 2 numbers that you give them (one odd and one even number of digits).

CODE 39

BAR CODING

▪ MATHEMATICS ▪



Design Brief IV: Is the UPC-A Scheme Sufficient?

Problem: To use the counting principle to find the number of companies that can be coded into the present Universal Price Code (UPC-A) bar code system.

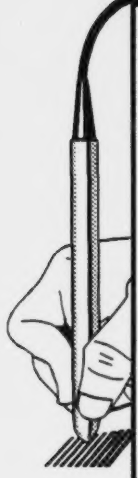
Mathematical Competencies Used: Use of the counting principle for combinations. In terms of processes used, the students will be using problem solving strategies, reasoning, and mathematical communication.

Situation: Given that the manufacturer's part of a 12-digit bar code consists of 5 digits, any one of which may be 0 through 9 (repeated digits like 00220 are allowed), how many different companies can be coded into this UPC-A system? The counting principle of probability allows one to find the number of possible events there are in a given situation. Have students work in groups to solve the following two counting problems. If John has 3 pairs of pants and 4 shirts, how many different outfits can he wear? If an interior decorator is designing the interior of an apartment building and has 3 colors to use as the primary wall color, 2 different tints to use for trim, and 4 different colors to use for accent purposes, how many different color schemes can be created? Now, have the groups address the original problem. Have students discuss whether or not they believe that the number they have calculated is sufficient for the number of companies applying for a UPC-A number. An opportunity to report on group findings and conclusions should be given along with reasons for conclusions made.

Discussion: The first problem involving pants and shirts could be solved with a diagram showing that for each pair of pants, each of the four shirts could be worn, making a total of 12 different sets of clothes. An organized list might be used to show that for the decorating problem there are 3 X 2 X 4 = 24 ways of decorating an apartment before a repeat scheme has to be used. There are 10 numbers to choose from on each of 5 positions for a total of 10 X 10 X 10 X 10 X 10 = 100,000 companies (or $10^5 = 100,000$). Have students make conjectures about what they believe the counting principle is from the three problems they have worked. Do these conjectures work for additional problems?

Homework: Have students find the number of car (not truck) license plates that can be made for a particular county in Indiana given that the scheme is to put the number of the county (based on alphabetical order) first, a letter of the alphabet second, and a four digit number third (examples 26B2519 & 53F4471). How many cars can be licensed for each letter of the alphabet? For each county number? What if a county runs out of numbers to use?

CODE 39



Design Brief V: Revising the UPC-A System

Problem: Use the counting principle for combinations to find a new encoding system similar to the UPC-A scheme that will allow a greater number of companies to be encoded.

Mathematical Competencies Used: Use of the counting principle for combinations. In terms of process skills, the students will be using problem solving strategies, reasoning, and mathematical communication.

Situation: Given that the manufacturer's part of a 12-digit bar code used to consist of 5 digits, any one of which may be 0 through 9 (repeated digits like 00220 are allowed), how many different companies could be coded into this UPC-A system? Let us assume for a minute that the calculation for the number of companies that can be coded is not sufficient (it is not). Have students brainstorm in groups on some ways to increase the number of companies that can be included in a bar code system. (As of July 1, 1992, the number of digits designated for the manufacturer was increased to 7. How many companies can now be coded?)

Discussion: Assuming the old 5 digit code system, there are 10 numbers to choose from on each of 5 positions for a total of 10 X 10 X 10 X 10 X 10 = 100,000 companies. For the second part of the problem, have students come up with a bar code system based on the results of the brainstorm session or any other ideas including: increasing the number of numbers used in the company code from 5 to 7 or 8; using letters instead of numbers (increasing the number of possibilities for each choice from 10 to 26); or keeping the same basic format as the UPC-A but adding some characters to the numbers 0-9, such as *, #, &, @, +, ☼, etc. Have the students work in groups to first find the number of companies that could be coded into their new system and if it seems like a profitable number, have them see if they can devise codes for each of their symbols. There are some questions to consider. Is it possible to develop a binary code system similar to the UPC-A system that could include unique representations of all 26 characters of the alphabet? Would it be feasible to increase the number of spaces in the bar code for each number from 7 to a number such as 9? If the number of spaces for each number was increased, how much would that increase the actual size of the bar code on the product?

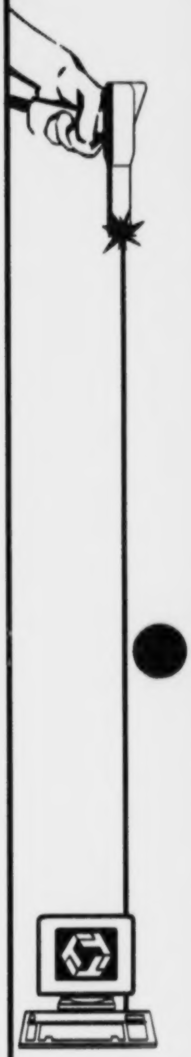
Homework: Have students take three companies from the stock exchange section of the newspaper and assign them 5-digit (or the appropriate number based on their system) numbers. Then have them develop a bar code for each company based on their system.

DESIGN BRIEF

BAR CODING

▪ MATHEMATICS ▪

TECH PREP - PURDUE UNIVERSITY 1992



Design Brief VI: Coding Errors--Which Ones Get Through?

Problem: To investigate one of the errors that can occur in a bar code system.

Mathematical Competencies Used: Problem solving with modular arithmetic (mod 10). In particular, students will be asked to cooperatively solve a problem that may be approached in several different ways.

Situation: The UPC-A is designed with a check number (the 12th number in the sequence) that catches all single number errors in the modulo 10 numbering system. However, if two numbers are in error, there is the possibility that the two mistakes will "cancel each other out" and the scanner will not catch the errors. Although any two numbers in the encoding scheme that were in error could create a problem, the most likely mistake in recording two numbers is that of transposition (for example, 68294 → 68924). Because of the way that the system is designed, when two numbers are transposed most of these errors are caught by the mod 10 coding formula and resulting check number, but some errors are not picked up. In order for the UPC-A number to be valid, the twelve numbers in the bar code must satisfy the following condition: $3a_1 + a_2 + 3a_3 + a_4 + 3a_5 + a_6 + 3a_7 + a_8 + 3a_9 + a_{10} + 3a_{11} + a_{12} \equiv 0 \pmod{10}$. A transposition error would go undetected if numbers x and y fit the following form: $3x + y \equiv x + 3y$. Have groups of students find the transposition errors that would create problems for the user of the UPC-A system by virtue of the fact that they are not detected. Because of the differences in learning styles of students some groups may approach this problem in a very disorganized looking trial-and-error format, some may use an organized list or table, and some may try to use a mod 10 congruence statement to find the kinds of numbers that would give the same mod 10 value despite being transposed.

Discussion: There are many different two digit numbers that the students will have to consider (10 numbers to choose from for each of the two digits, making a total of 10 X 10 or 100 permutations of numbers). However, groups will not even have to consider the possibility of an error of transposition if the two digits are identical. Thus, the number of possible permutations of numbers that have an opportunity to be transposed is 10 X 9 = 90. Ordered pairs that go undetected are: (0,5); (1,6); (2,7);...(9,4)--a total of 10 pairs. These pairs all fit the equation $|a - b| = 5$. Have students speculate on an encoding scheme that would remedy the problem created by the undetected transposition errors.

Homework: Have students take an encoding scheme from the in-class speculations and check to see if any transposition errors could occur.

CODE 39

DESIGN BRIEF

BAR CODING

▪ MATHEMATICS ▪

TECH PREP - PURDUE UNIVERSITY 1992

Design Brief VII: Coding Errors--Comparing Two Bar Codes

Problem: To investigate one of the errors that can occur in a bar code system with an eye toward the actual probability that a transposition error will not be detected.

Mathematical Competencies Used: Probability--in particular the definition of probability and problems that involve theoretical probability that can be figured mathematically. These problems could also be done in an experimental manner to check against the calculated value.

Situation: The UPC-A is designed with a check number (the 12th number in the sequence) that catches all single number errors in the modulo 10 numbering system. However, if two numbers are in error, there is the possibility that the two mistakes will "cancel each other out" and the scanner will not catch the errors. A particular problem in recording numbers is that of transposing two numbers (for example, 35742 → 35472). Because of the way that the check system is designed, when two numbers are transposed only those combinations of numbers a and b that meet the condition $| a - b | = 5$ go undetected. Have students figure the probability of a two-digit transposition error going undetected in the UPC-A system. Another coding scheme has been developed by IBM. It also detects all single digit errors, but like the UPC-A system it has problems with some transposition errors. The only errors in the IBM system that go undetected, however, are those of the form $| a - b | = 9$. What is the probability that a transposition error will go undetected in the IBM system?

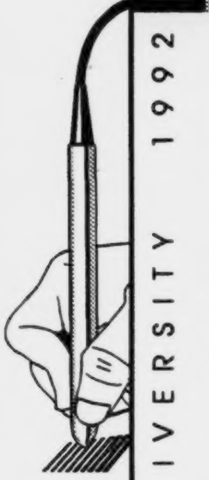
Discussion: There are 10 numbers to choose from for each of the two digits, making a total of 10 X 10 or 100 permutations of numbers for the two digits in question, with one exception. There is not even the possibility of an error of transposition if the two digits are identical. Thus, the number of possible permutations of numbers that have an opportunity to be transposed is 10 X 9 = 90. For each number "a" that is chosen, a unique number "b" can be chosen that satisfies the absolute value condition. Ordered pairs that go undetected are: (0,5); (1,6); (2,7);...(9,4)--a total of 10 pairs. Therefore, the probability of an error of transposition in the UPC-A system is 10/90 or 1/9 or 11.1%. The IBM system has problems only with ordered pairs (0,9) and (9,0). Thus, the probability of an error not being detected is 2/90 or 2.2%.

Homework: Have students discover the complement rule of probability by asking them to find the success rate for detecting errors of transposition.

CODE 39

BAR CODING

▪ MATHEMATICS ▪



Design Brief VIII: Using Binary Numbers

Problem: To investigate the binary number system.

Mathematical Competencies Used: The use of an alternate number system (base 2) as opposed to the standard decimal (base 10) system.

Situation: The binary number system is used to develop the code used for the UPC-A system. This lesson will investigate this base 2 system which is also an integral part of computer technology. First let us compare the base 2 and base 10 systems to show their similarities and differences. The base 10 system is a place value system consisting of the following places: ones place (10^0), tens place (10^1), hundreds place (10^2), thousands place (10^4), and so on. The base 2 system consists of a ones place (2^0), twos place (2^1), fours place (2^2), eights place (2^3), and so on. In base 10, the largest numeral that can be used in a particular place is 9, with the range of possible numbers being 0 through 9. In base 2, the largest numeral that can be used is 1 with 0 being the only other choice of digit. The number 13 in base 10 would be represented by the number 1101 in base 2 with the 13 being made up of 1 eight, 1 four, 0 twos, and 1 one. The number 1110010 in base 2 which is the right hand parity code for zero (see Table 1--UPC Encoding Scheme) in the UPC-A system, is 114 in base 10. Have students work in groups to convert the left and right hand parity numbers for 0, 1, and 2 into base 10. Are there any conclusions or conjectures that can be made based on these data? If any conjectures are made, test them by continuing the base conversion on the codes for 3.

Discussion: The base 10 conversion of the codes for 0 (base 2) are 13 and 114 for the left and right characters respectively. For 1, the base 10 equivalents are 25 and 102 and for 2, the base 10 equivalents are 19 and 108 respectively. As far as conjectures are concerned, several options are available (which makes this a nice activity). Students might observe that the two numbers in base 10 for each encoding add to 127 (base 10). They might notice that there are always a total of 7 "ones" and 7 "zeros" for each code. Students might see that between the two binary numbers in the left and right parity there is always one-and-only-one "one" in each of the seven base 2 places. Thus, the total for the two numbers in base 10 would necessarily consist of 1 sixty-four, 1 thirty-two, 1 sixteen, 1 eight, 1 four, 1 two, and 1 one.

Homework: Try to find additional left-right parity combinations that fit the schemes discovered in the activity. How many more symbols could be encoded?

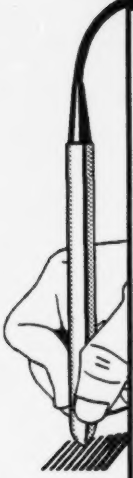
CODE 39

DESIGN BRIEF

BAR CODING

▪ MATHEMATICS ▪

TECH PREP - PURDUE UNIVERSITY 1992



CODE 39

Design Brief IX: Measurement and Area

Problem: To develop a sense of surface area needed for a UPC-A bar code.

Mathematical Competencies Used: Measurement, surface area, & percentages.

Situation: The UPC-A bar code utilizes a portion of the space on a package. If the package is small, this may be a significant percentage of the space available for marketing and federally mandated information. Part of the bar code consists of "quiet space" that precedes and concludes the actual bar code. Then the bar code itself is made up of a Guard pattern on each end which is 3 spaces wide (2 narrow bars separated by a narrow space), a Center pattern 5 spaces wide (3 narrow spaces separated by 2 narrow bars), and 12 character representations consisting of 2 bars and 2 spaces each (some of the bars and spaces are wider than others with each number occupying the total space of 7 narrow bars and spaces). Have students bring in several products with UPC-A bar codes. First have students work in groups to determine the approximate number of narrow bars that could fit into the bar code space from quiet zone to quiet zone. After measuring the length and width of the bar code in either metric or standard units, convert it into area. Then find the surface area of the rectangular prism that is the package. For the area project, have students find the best method for them to use in finding the amount of surface (taking the box apart, finding the area of just three surfaces, finding the perimeter of the base of the box...). Now have the groups compute the percentage of the box that is occupied by the bar code. Does the amount seem significant (also consider other "wasted" space such as the bottom of the box)? Are some bar codes smaller than others? Is there a fairly typical size that shows up on many products?

Discussion: The UPC-A code consists of a left hand quiet zone 11 spaces wide, a right hand quiet zone 7 spaces wide, 2 guard patterns 3 spaces wide, a center pattern 5 spaces wide, and 12 number representations each 7 spaces wide. The total width of the bar code in terms of "spaces" is 113. The UPC-A bar code at 100% magnification is approximately 1.5 inches horizontally and 1.0 inches vertically. If students are using the metric system, those approximations would be 3.8 cm by 2.5 cm. Students may want to get more precise measurements in terms of millimeters to use in finding the approximate width of a single space.

Homework: Students may want to test some of the conjectures they made in terms of measurement and area with additional products. Another project would be to enlarge a bar code by a known amount (microscope or copy machine) to get a width measurement on a single bar.

OTHER MATH BAR CODE TOPICS FOR CONSIDERATION

Statistics: Lesson could focus on entry errors such as approximately 1 in 300 for human keyboard entry and 1 in 3,000,000 for bar code entry. Students could collect data from users of keyboard entry and bar code scanners that would either validate or dispute these statistics. Data on the cost to the company for these kinds of errors could be collected. Another set of statistics that could be compiled is the cost of personnel for the various means of data entry as opposed to the cost of the technology being used. Students could then make conclusions concerning their findings as to the most cost-efficient means of data entry.

Statistics: Lesson could focus on the cost of various kinds of scanners (hand-held wand about $100, helium-neon $600-$2000,...), the error-rate of each or the error-rate of the operator of each, and the type of material being scanned (low-priced retail goods or blood in a blood bank). Students in this applied problem would have to gather the information, set up some guidelines, make a decision, and then justify it to the "board."

ISBN Code: The International Standard Book Numbers are a number code that includes a language or nation indicator, a number for the publisher, a number for the published article or book itself, and a check number. The check number is based on a modulo 11 scheme. A lesson of this type would utilize equation solving skills and modular arithmetic.

Code 39: The "3 of 9" code scheme utilizes 3 wide elements (bars or spaces) and 6 narrow ones. It allows more characters to be coded (44 in all) and may also have a check number. Have students compare code 39 to the UPC-A system.

Developing a Bar Code: Students could be challenged to create a bar code that utilized 2-D symbology (for example, the length and width of the bars would hold meaning instead of just the width).

Left-Right Parity: Students could investigate the coding scheme in UPC-A where the left-right parity is of utmost importance in terms of bi-directional scanning. Some of the findings might include the total amount of "barred" space for any number when the left and right codes are combined is seven, with every "place" having a bar and that the left-hand code has an odd number of bars (3 or 5) while the right-hand code has an even number of bars (2 or 4). Also, the seven spaces allowed for each number are always filled by 2 bars and 2 spaces of width varying from 1 to 4 spaces wide. A question that could be posed is, "Are there any more characters that could be coded using the existing UPC-A scheme?"

STUDENT GLOSSARY

Binary number system - Base two number system as opposed to the decimal (base 10) system which is the standard system. For example, 5 in base 10 is 101 in binary (1 four, no twos, and 1 one).

Complement Rule - The sum of the probabilities of an event happening or not happening is one [P(a) + P(not a) = 1]. For example, if the probability of rain is .4, the probability of not having rain is .6.

Congruence ($\equiv$) - Symbol used to describe numbers in modular arithmetic that are equivalent to each other. These numbers have the same remainder when divided by the modulus. In mod 10, for example, $23 \equiv 13 \equiv 3$.

Counting Principle - Method used to find the number of ways of making several decisions in succession. To find the number of ways, multiply the number of choices that can be made in each decision.

Modular Arithmetic - An arithmetic system based on the remainder obtained when dividing a given number by the base number which is called a modulus.

Permutation - Any ordered arrangement of a set of objects. In the coding permutation (1248), 1 is coded as 2, 2 becomes 4, 4 is coded as 8, and 8 becomes 1.

Probability - The chance or likelihood of an event happening. The theoretical probability of an event happening is defined as the number of favorable outcomes divided by the total number of outcomes. When rolling a die, for example, the chance of getting an even number is 3/6 because 3 of the 6 numbers on a die are even.

REFERENCES

Gallian, J. A., The Mathematics of Identification Numbers, *The College Mathematics Journal* 22 (1991) 194-202.

Gallian, J. A. and S. Winters, Modular Arithmetic in the Marketplace, *American Mathematical Monthly* 95 (1988) 548-551.

Gumm, H. P., A New Class of Check Digit Methods for Arbitrary Number Systems, *IEEE Transactions on Information Theory* 31 (1985) 102-105.

Gumm, H. P., Encoding of Numbers to Detect Typing Errors, *International Journal of Applied Engineering Education* 2 (1986) 61-65.

Jacobs, Harold R., *Mathematics: A Human Endeavor*, San Francisco: W.H. Freeman and Company (1982) 378-409, 510-517.

Knill, George, International Standard Book Numbers, Mathematics Teacher 74 (1981) 47-48.

Peck, Lyman C., *Secret Codes, Remainder Arithmetic and Matrices*, Reston, VA: National Council of Teachers of Mathematics (1975) 1-11, 29-35.

Thornton, Davey S., Check Out UPCs, *80 Micro* 46 (1983) 114-120.

Wood, Eric F., Self-checking Codes--An Application of Modular Arithmetic, *Mathematics Teacher* 80 (1987) 312-316.

Module 5:
AN INTERDISCIPLINARY MODULE ON BARCODING

SCIENCE DESIGN BRIEFS

by

Mary B. Nahkleh
Assistant Professor of Science Education
Purdue University

Abstract

This unit presents sample projects, called Design Briefs, for science teachers who make use of the material presented in the "Background for Teachers" section of this module. These projects were designed to be used in concert with projects in Mathematics Design Briefs, Language Arts Design Briefs, and Technology Design Briefs.

Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

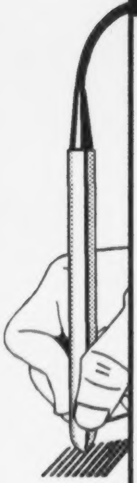
The Role of Science in the Interdisciplinary Tech Prep Unit

This unit on bar coding technology is designed to be integrated into your science curriculum in cooperation with other Tech Prep teachers in your school. As a science teacher, your interest is in helping your students understand how science enters into the development of a technology such as bar coding. It does so at various stages, from research and application of the technology to the production and testing of the technology.

The unit "Scanner Analysis" will allow your students to become involved in the testing of scanner technology, in much the same way as industrial product scientists function. As a team of four or five members, your students will conduct independently devised experiments on a particular bar code scanner. The collective research that they do will be used to compile a report to the "company management" to suggest whether or not the company should purchase this particular scanner system.

As science teachers, we are also interested in helping our students understand the relationship of science to technology. From this aspect, the units on "Spectroscopy" and "Holography" have been written. Just as bar code scanners can instantly identify a product code by the absorption pattern of light rays formed by the bar code, spectrophotometers can help scientists to identify elements and compounds by the absorption pattern created when these elements and compounds absorb various forms of energy. The resulting spectra can be thought of as the product code of the element, each one unique to the individual element.

Bar code scanners utilize a laser for their light source. The unit on "Holography" provides the student with the opportunity to explore yet another application of laser light and, in the process, learn about the technology used in the production of holograms. The science behind holographic imaging is as simple to understand as the science behind bar code technology. This unit should serve as another example to the student of how science can be used to take the mystery out of the "seemingly mysterious" technologies of today and tomorrow.



Design Brief I: Scanner Analysis

Problem:

You have been discussing bar coding technologies in several of your Tech Prep classes. In Tech Prep Physics, you will be investigating several aspects of this technology. This project will provide you with an opportunity to pursue several open-ended investigations which you and your team will design.

Project Overview:

You will be part of a consulting firm whose job is to determine if a particular scanner system should be purchased for your client, a company which has hired you to test this scanner system. Once your consulting firm has been established, you will decide upon who is the president of your firm, who is in charge of laboratory research on the scanner system, who is in charge of gathering technical data on the scanner system etc. Each member should have a well-defined roll to play within your firm. Your firm will then set about to investigate various aspects of the scanner system which help you to determine whether or not this system should be purchased.

CODE 39

Competencies

At the termination of this unit, your consulting firm should be able to:

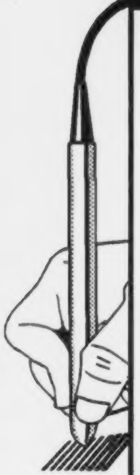
1. Produce data which demonstrates the limitations of a particular scanner which you will study.

2. Using the data you collected, produce and present a document that will convince your client that they should purchase this particular type of scanner or, alternatively, suggest why they should not elect to purchase this scanner.

Activities

This unit will require your firm to investigate one of the five scanner systems on loan to the science department from a local business. Your firm will be assigned one of these scanner systems. You will then conduct research on this scanner. Your goal is to design and carry out as many experiments on this scanner as you can in the <four week> period which we will have to work on this unit. Your research will involve gathering information on the technical specifications of your scanner, cost of the scanner and other pieces of information which will help you to build your case for or against the purchase of this scanner.

You are serving in the capacity of a consulting firm for a company of your choice. You will decide what the company does and what its needs are for this scanning technology. Your goal is to produce a document which details the work your consulting team has done and your suggestion to implement or not implement this particular scanner.



CODE 39

Design Brief II: Scanner Research Document

I. A brief description of the company your team is working for and its need for this technology. Further, describe in this section your consulting firm members. Detail each of their duties in this project. For instance, John Smith is director of this team and will serve as the primary collector of technical data about the scanner. Jane Thomas will oversee the laboratory research portion of the investigation etc.

II. A description of the experiments you have performed on this scanner. Include the design of the experiments, dates of the experiments and the participants. Tabulate the data and report the results of the experiments.

These experiments should investigate aspects of the scanner which are of importance to your specific company's needs. They should include, but need not be limited to, investigations of aperture size, depth of field, first read rates, optical throw, resolution, and scan rates. The experimental design is left for your firm to determine. You may wish to contact an actual company in the community that uses this particular technology to gather some of your information and gain insight into possible avenues of experimentation you may desire to pursue.

III. A summary of the research you have done regarding this scanner's capabilities and limitations and your recommendation for purchasing the scanner. Do not restate the experimental design here, but rather, summarize the cumulative findings of the experiments and show how they support your recommendation for the scanner.

Final Presentation

As the culminating project, your consulting firm will make a formal presentation of your findings to the company management (the rest of the class). All members of the consulting team must participate in this presentation. Remember that this presentation is where your firm has the opportunity to demonstrate its ability to do consulting work for this and other companies. Your consulting firm's future is riding on this presentation. Therefore, it is crucial that a professional presentation be prepared. Regardless of how well your research has been performed and no matter how irrefutable your data may be, it will all be for nothing if your final presentation to the company management lacks coherence, poise, and professionalism.

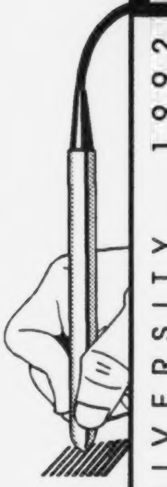
Resources for the Teacher for Design Brief II

Davis, J.C. Introduction to spectroscopy, Part II. Chemistry. 1975. 48 (1).

Davis, J.C. Introduction to spectroscopy, Part III. Chemistry. 1975. 48 (5).

Williams, B. Inexpensive apparatus for spectrophotometric experiments. Chemistry. 1968. 41 (3).

Glossary of Terms. (For students to define)
bar code scanner--
aperture size--
depth of field--
first read rates--
optical throw--
resolution--
scan rates--



Design Brief III: Spectroscopy

Introduction to Students

You have been exposed to bar coding technology in several of your Tech Prep courses. As you have learned, that technology utilizes reflected light energy from a laser to identify products which are bar coded. Each product is given a specific code which identifies that product only. The same is true of elements and compounds.

Each element has its own unique fingerprint which is determined by the energies of the electrons in that element's outer shell. When, for instance, we excite the outer (or $3s^1$) electron in a sodium atom, that electron is briefly transferred to higher energy states by absorbing light of a specific wavelength. As the electron returns to the original energy level, energy is released at wavelengths which we perceive as yellow light. If that yellow light is passed through a prism or diffraction grating, you would find that the yellow light is actually composed of two specific wavelengths of light which show up as bright yellow lines (589.5 nm and 588.99 nm). We call those bright lines the emission spectrum of the element. It is the element's "fingerprint" and it is unique to that element. When hydrogen gas has a current passed through it, the emitted light from the hydrogen looks red/pink. If that emitted light were passed through a prism or diffraction grating, you would see an emission spectrum consisting of four primary lines (red at 656.3 nm, blue at 486.1 nm, blue-violet at 434.0 nm, and violet at 410.1nm). This spectrum is unique to hydrogen alone. You might think of it as its bar code!

Project Overview

This unit will introduce you to the methods of spectroscopy, specifically to flame emission spectroscopy.

CODE 39

Competencies

At the completion of this unit you should be able to:
1) explain flame emission spectroscopy and its relationship to elemental analysis.

2) describe the main parts of a spectrometer (source, analyzer, detector, and display) and what function each serves.

Activities

A. Flame Tests. Using the Bunsen burners in the laboratory, you will, in cooperation with your partner, determine the flame color emitted by various metal salts when held in the colorless burner flame. The exact procedure for this will be provided.

B. Spectral Analysis. Once you have completed the flame test activity, you and your partner will join another pair of researchers to perform another flame test. This time, however, you will not just be recording the color of the flame. You will be passing the light through a simple spectrometer and gathering wavelength data on the emission spectra for various metals. More specific instructions will be provided for this procedure.

C. Spectrometer Technology. The term "spectrometer" refers to a wide range of instruments which differ essentially only in their source of electromagnetic energy. Several simple spectrometers, like those you used in the previous activities, are available in the laboratory for you to view. The covers have been removed and the working parts of the spectrometer exposed. Make a drawing of what you see. Then, on your drawing, identify the source, the analyzer, the detector and the display. Briefly describe how each works in the overall functioning of the spectrometer. You may use any reference you have available for this activity. Library research may be productive. Visiting a local lab would be another route to take for this activity.

Assessment

Activities A and B will require general laboratory data collection. Present the data in a standard laboratory report format. One report per group is adequate.

Activity C will require the schematic/drawing to be submitted with the required parts identified on the schematic. The research portion of Activity C should be presented in the form of a short paper which details how each part works in the overall performance of the spectrometer.

Resources

Davis, J.C. Introduction to spectroscopy, Part II. Chemistry. 1975. 48 (1).

Davis, J.C. Introduction to spectroscopy, Part III. Chemistry. 1975. 48 (5).

Williams, B. Inexpensive apparatus for spectrophotometric experiments. Chemistry. 1968. 41 (3).

Glossary of Terms

diffraction grating--a glass or polished metal surface having many very fine parallel grooves or slits cut in the surface. They are used to produce optical spectra by diffraction of transmitted or reflected light.

diffraction pattern--the image formed on a screen or a photographic film caused by the diffraction of electromagnetic radiation such as visible light or X rays.

flame test--a qualitative procedure utilizing a Bunsen burner flame to excite the electrons in metal salts. As the electrons return to their original energy states, light of a characteristic frequency (color) is emitted.

metal salts--typically metal halides used in flame tests.

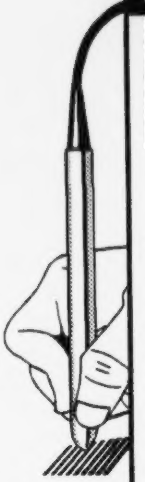
spectral analysis--any of various procedures used to study the energy transitions of electrons within atoms or molecules. Wavelengths at which solutions, gases, or solids absorb electromagnetic radiation, from ultraviolet to infrared, are read from the spectrometer. This analysis provides information about structure.

spectrometer--any of several instruments containing four basic elements (a source of electromagnetic radiation, an analyzer, a detector, and a display) which are used to determine the electronic or molecular structure of a substance.

DESIGN BRIEF

BAR CODING

SCIENCE



CODE 39

Design Brief IV: Holography

Introduction to Students

As you have learned in your work with bar coding, the laser is an extremely useful light source when used in conjunction with today's technologies. This unit will provide you with further insight into the use of lasers.

Project Overview

(from Linthwaite & Shimmens) Holography comes from the Greek word meaning whole writing. It is a process by which an object illuminated by laser light is made to produce interference fringes in a photosensitive medium, such as a photographic emulsion. Re-illumination of the developed interference pattern by light of the same wavelength produces a three-dimensional image of the original object. The images seen by this process have the same appearance as the original object, including the differences in perspective one obtains with a change of the viewer's position--a three-dimensional image. The principles of holography were first defined by Dennis Gabor of the University of London, for which he earned the Nobel prize in physics in 1971.

In this project you and your group will be learning about the process of holography and creating holographic images.

Competencies

At the completion of this unit you should be able to:
1) describe how holographic images are formed and the laser's part in that formation.
2) create a holographic image.
3) detail the parameters which effect the production of a holographic image.

Activities.

A. The first need you have is to learn about holography in general. To this end, you will be conducting an initial library search on holography.

B. Using the laboratory, your group will produce a holographic image. The necessary materials and apparatus will be provided. The apparatus will be set up for you to adequately produce the desired image.

C. *(from T. Altman)* To produce a hologram, one captures the light waves as they reflect off an object. Several variables combine to make the holographic image: the direction, phase angle, and intensity of the reflected light. Changes in any of the wave characteristics produce not just a fuzzy hologram, but no image at all. You will be investigating these parameters in the laboratory which effect the production of holographic images.

D. Visit a local museum that maintains a holography exhibit. <Museums of Science & Industry, Children's Museums etc.>

Assessment

Activity A will require you to submit a report of your library research on holography. The report should identify adequately the major aspects of holographic imaging.

Activity B will be assessed simply by producing a hologram of any object which your group chooses.

Activity C will require you to gather and analyze data on holographic imaging. Your group will determine which parameters to research in the production of the holographic image. Record the data and submit a group report of the data. You should have holograms representing each of the experimental parameters which you adjusted in this research.

Resources.

Altman, T. Holography and interferometry. The Physics Teacher. 30, 1992, 220-3.

Latham, R. Holography in the science classroom. The Physics Teacher. Oct. 1986, 395-400.

Linthwaite, M. and Shimmens, C. Simple method of producing good-quality holograms without the need for expensive equipment. The Physics Teacher. Sept. 1987, 382-3.

Glossary of Terms

Hologram--an image produced by a piece of film that can generate the same light-wave information as is reflected from a real object. The hologram image appears in three dimensions as though it was the real object. Simple examples are various credit card surfaces, breakfast cereal boxes and magazine covers.

Interference patterns--a pattern created when two or more waves of the same frequency combine to form a wave in which the disturbance at any point is the algebraic or vector sum of the disturbances due to the interfering waves at that point. Constructive interference amplifies the wave; destructive interference flattens the wave.

Laser light--a coherent light produced by any of several devices. The incident electromagnetic radiation of mixed frequencies is converted and amplified to one or more discrete frequencies of visible light.

Module 5:
AN INTERDISCIPLINARY MODULE ON BARCODING

TECHNOLOGY DESIGN BRIEFS

by

Duane D. Dunlap
Assistant Professor of Industrial Technology
School of Technology
Purdue University

Abstract

This unit presents sample projects, called Design Briefs, for technology teachers who make use of the material presented in the "Background for Teachers" section of this module. These projects were designed to be used in concert with projects in Mathematics Design Briefs, Science Design Briefs, and Language Arts Design Briefs.

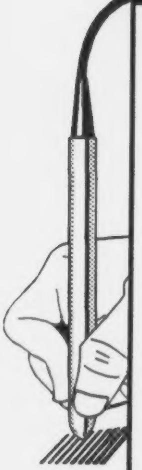
Indiana Tech Prep Training Manual: Division II
Sponsored by:
The Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

The Role of Technology in the Interdisciplinary Tech Prep Unit

The objective of the technology teacher is to cooperatively structure classroom and laboratory activities with mathematics, science, and language arts teachers so that activities are truly interdisciplinary. Teaching technology, in this interdisciplinary example unit, bar coding can be fun, exciting, and thought provoking! This example of interdisciplinary instruction for Tech Prep can provide the framework or foundation for implementation. However, specific regional curriculum development should build upon this sample unit of instruction by including the efforts and energies of parents, business, industry, postsecondary, and secondary institutions. Other Tech Prep teachers in your school will be looking to you for answers in the use and application of bar code technology within their own curriculum. The technology teacher should reciprocate by finding out what can take place in the other academic areas of Tech Prep (in particular bar coding alliances through application and integration) that can be applied in their classroom and/or laboratory. It is the responsibility of the technology teacher to enhance, modify or develop activities that work toward the articulation and application of mathematics, science, and language arts into daily technology lessons and activities.



Design Brief I: I've Been on The Line

Introduction: Bar codes are those little vertical lines you see on all retail goods you purchase. Bar codes have been utilized for over 20 years by the supermarket industry. When was the last time you were in a retail or grocery store that did not use bar codes and scanners to tabulate your purchase? Bar coding is gaining tremendous use outside the grocery store or the department store you might frequent. Global competition threatens to force virtually all companies small or large to "bar code or perish". Have you checked out a book from your city library or university, only to have it "scanned" before handed to you?

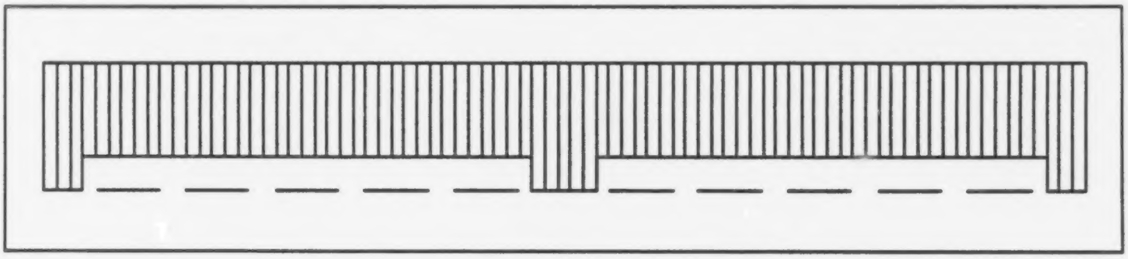
Problem: You are in the process of selling a newly designed product to all department stores in the United States. However, before a department store will accept shipment of your product, a UPC-A bar code must be developed. You must act alone and develop a suitable UPC-A bar code. You will use the Tech Prep UPC-A bar code sheet supplied by your teacher.

CODE 39

Name ____________________
Date ____________________
Class ____________________
Instructor ____________________

Table 1 - UPC ENCODATION SCHEME

NUMBER VALUE	LEFT CHARACTERS (ODD PARITY)	RIGHT CHARACTERS (EVEN PARITY)
0	0001101	1110010
1	0011001	1100110
2	0010011	1101100
3	0111101	1000010
4	0100011	1011100
5	0110001	1001110
6	0101111	1010000
7	0111011	1000100
8	0110111	1001000
9	0001011	1110100
LEFT AND RIGHT GUARD BARS	101	101
CENTER PATTERN	01010	

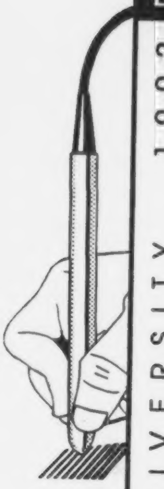


DESIGN BRIEF

BAR CODING

■ TECHNOLOGY ■

TECH PREP - PURDUE UNIVERSITY 1992



Design Brief II: Move that Pallet, Stack that Box

Introduction: Industrial applications of bar coding were first developed by the Westinghouse Corporation in the early 1970's to tag and identify railroad cars. Bar codes affixed to the exterior side of railroad cars, allowed operators to determine content and destination of the cargo.

CODE 39 (3 of 9) is the most dominant, flexible, widely used standardized and supported industrial bar code symbology used in manufacturing. Code 39 is not only used in manufacturing, but has been applied effectively in hospitals, libraries, universities, and government agencies. The name Code 39 comes from its 3 out of 9 structure where 3 of the 9 elements (bars and spaces) are wide and the remaining 6 are narrow of the code's 5 bar and 4 space makeup. The standard Code 39 symbology encodes 44 different alphabetic, numeric, and graphic characters.

Problem: You have just recieved a job in a manufacturing company that produces bicycles. Your job is to develop a Code 39 bar code label that identifies the make and model of each bicycle. Use the Tech Prep Code 39 worksheet supplied by your teacher to develop your bar code label.

CODE 39

Directions: *Using Code 39 symbology specifications, create a 3 of 9 bar code symbol for your three initials (Alpha Characters).*

1. *In the spaces below the grid, print the human readable characters you wish to translate into 3 of 9 bar code. Remember that the first and last characters are reserved for the START and STOP character.*

2. *Referring to Table 1 in the middle of this page, fill in the bars and spaces code for the START and STOP characters first and then for the remaining characters you have chosen. Draw tick marks down from the beginning and ending of each character. BE NEAT! Follow closely during the demonstration, if you don't understand something, please ask.*

TABLE 1 CODE 39 Code Configuration

CHAR.	PATTERN	BARS	SPACES	CHAR.	PATTERN	BARS	SPACES
1		10001	0100	M		11000	0001
2		01001	0100	N		00101	0001
3		11000	0100	O		10100	0001
4		00101	0100	P		01100	0001
5		10100	0100	Q		00011	0001
6		01100	0100	R		10010	0001
7		00011	0100	S		01010	0001
8		10010	0100	T		00110	0001
9		01010	0100	U		10001	1000
0		00110	0100	V		01001	1000
A		10001	0010	W		11000	1000
B		01001	0010	X		00101	1000
C		11000	0010	Y		10100	1000
D		00101	0010	Z		01100	1000
E		10100	0010	-		00011	1000
F		01100	0010	•		10010	1000
G		00011	0010	SPACE		01010	1000
H		10010	0010	*		00110	1000
I		01010	0010	$		00000	1110
J		00110	0010	/		00000	1101
K		10001	0001	+		00000	1011
L		01001	0001	%		00000	0111

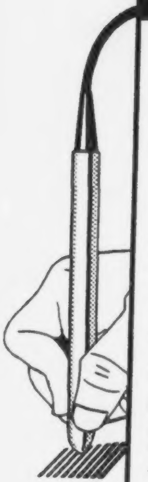
EXAMPLE

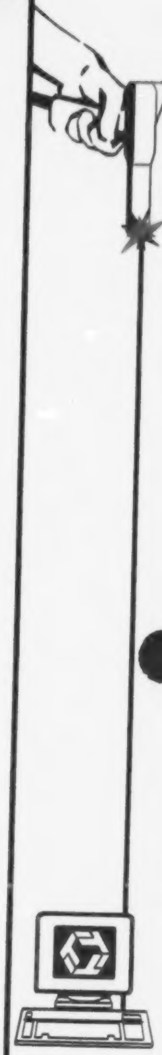
*

E C D

___ ___ ___

What is the print ratio and why?





Design Brief III: Clock Me In!

Introduction: How many times have you rushed to your technology class, only to sit and wait before you could begin working? Believe it or not, this problem arises in many businesses and companies too. Today we are going to design a time and attendance badge to automate this process for the entire class. Your badge should be the size of a drivers license or 2" by 3.35". Your badge should have fields of data for your name, social security number or other unique student identification number, class name and period, school year, and any other information deemed appropriate by your teacher. To make your badge really unique, fine a graphic logo or emblem to put in the left or right upper corner of your badge. The only field initially that needs to be bar coded is your student identification number or social security number. Your teacher may want to add more bar coded fields later. Your identification badge should have a high contrast. Meaning, it would probably be best if you used a white background and back ink for your badge.

Problem: Working in groups, design a badge that contains the information mentioned above. Make a large scale poster of your design to share with your classmates. The entire class will choose the best design. Remember we can only have one design per class.

CODE 39

TECHPREP

INDIANA

TRAINING MANUAL

DIVISION III

Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

August 1992

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

Division III Table of Contents

Division III Table of Contents iii

Overview: Staff Development Workshops

Abstract. Rationale for staff development materials in Division III. These materials are designed to be used in conjunction with material in Divisions I and II to prepare teachers and staff who will develop Tech Prep programs. Primarily of interest to those responsible for staff development.

- Introduction 3
- Why Tech Prep 3
- The dilemma 3
- The workshop approach 4
  - Concept defined 4
  - What is a concept structure 4
- Workshop organization 5
- Assumptions about participants 5
- Intended outcome 6

Workshop 1: Curriculum Development

Abstract. The first of four staff development workshops, this workshop introduces the use of concept structures as a curriculum building tool. Primarily of interest to those responsible for staff development.

- Overview 3
- Trainer material 4
- Trainee material 13
- DACUM analysis sheets 16

Workshop 2: Identifying Tech Prep Content

Abstract. The second of four staff development workshops, this workshop uses concept structures to identify course content and level. Primarily of interest to those responsible for staff development.

- Overview 3
- Trainer material 4
- Trainee material 9

Workshop 3: Developing Tech Prep Instructional Materials

Abstract. The third of four staff development workshops, this workshop uses concept structures to develop both group and individual instructional materials. Primarily of interest to those responsible for staff development.

- Overview 3
- Trainer material 4
- Trainee material 11

DIVISION III

OVERVIEW
STAFF DEVELOPMENT WORKSHOPS

By

Alan R. Suess
Professor of Industrial Technology
Purdue University

Abstract

This overview describes the rationale for the staff development materials contained in Division III. These materials consist of four workshops designed to enhance teachers' ability to define concepts, identify appropriate content, develop curriculum materials, and evaluate student outcomes. They are designed to be used in conjunction with other materials in this manual to prepare teachers who will develop Tech Prep programs. Primarily of interest to those responsible for staff development.

Indiana Tech Prep Training Manual: Division III
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

OVERVIEW: STAFF DEVELOPMENT WORKSHOPS

Introduction

The United States is unique among industrialized nations in its approach to delivering public education. The national constitution specifically assigns responsibility for public education to the several states. The State of Indiana further delegates responsibility for public education to the local education agencies. The nation has historically placed responsibility for educational policy at the local level.

This national tradition places very great demands upon teachers and administrators at the local level to be leaders in the development or selection of appropriate instructional materials. Contrast this educational responsibility to that of teachers in nations with highly centralized Ministry of Education mandated programs and materials.

This manual has been created with the full understanding of the responsibilities that have been vested in local teachers and administrators. *Its main objective is to provide an organizational strategy that will permit educational professionals with diverse backgrounds, interests, experiences, and frames-of-reference to better serve the student population targeted by Tech Prep programs.*

Why Tech Prep?

Tech Prep is the current manifestation of a program designed to meet the needs of "average" learners in the school environment. Concern for the needs of these average learners has a long tradition. Jean Jacques Rosseau, a philosopher considered the "father" of the French revolution, published the novel *Emile* about the education he considered appropriate for young French orphans. This work, published in the mid-1700s, was far from the first recommendation by an educational reformer urging the integration of theoretical and practical information into the education of children of average ability.

Average students *cannot* be unique -- for they comprise the largest segment in any public school! What is unique is their need for an educational program with more practical and integrated content. The recent explosion of knowledge coupled with the rapid changes in technology demand educating the young people of this nation in a manner that gives them the skills and knowledge to adapt to these changes throughout their productive lives.

The Dilemma

To be effective, Tech Prep programs must prepare and present performance-based instruction that is integrated across several academic areas. This calls for instructional and administrative skills that have been grossly underemphasized in preparation of educational professionals. Great emphasis has been placed on curriculum and course development on a discipline-by-discipline basis. Accommodating integration under these conditions can be very much like the often repeated story about the blind men in India who tried to describe what an elephant was like as a result of feeling only a single body part.

The Workshop Approach

Full educational integration requires a procedure that brings the efforts of all involved together into a single coordinated effort. The approach must be one that is independent of content selection and presentation practices in any academic discipline, but capable of adapting to all disciplines.

The method to be used in this series of workshops will be the development of *Concept Structures*. The procedure is based on the assumption that if a concept can be defined, its parts can be analyzed. It is the analysis of concepts that reveals the appropriate educational content. There is both skill and art (and sometimes a little black magic) in the identification and analysis of concepts for the development of educational programs.

Concept Defined. In general, a *concept* is an idea or thought that forms a similar mental image in the minds of many people. What is your concept of HORSE? If you share your immediate reaction with your workshop colleagues, it is highly likely that this first reaction will be surprisingly uniform. However, as you continue the analysis of the concept it is likely that those who know the most about horses will be able to define, classify and order several facts about horses that never occurred to most of us. For example, how large is a horse? If your experience is limited to observing horses in fields as you drive down the interstate, they are probably the size of large dogs. If your experience is more direct, you would probably have to ask the questioner to be more specific because of the wide variation in size among the many breeds of horses.

Great care must be taken in defining concepts. There is a very old joke that poses the question: "What is a camel?" The answer: A horse designed by a faculty committee!" Upon hearing the joke, a teacher with a great deal of experience working on committees asked: "Does this mean that a Dromedary (one hump) camel was designed by a small committee and the Bactrian (two hump) camel was designed by a large committee?" Poorly defined concepts can happen if the analysis of the concept is not complete. While it is true that horses and camels both have four legs, hairy skins, tails, eat grass, and can carry heavy loads long distances, horses and camels have several important characteristics that differentiate the animals.

What is a Concept Structure? In a curriculum sense, a concept structure is a series of subconcepts that support the main concept. The more precisely the subconcepts define and identify the main concept, the more useful the structure is in the organization and presentation of content. The procedure is neither new nor unique to education. Biology has long classified living things (most globally as animals and plants). Young children quickly learn to categorize information in parlor games such twenty questions by asking "Is it animal, vegetable, or mineral?" What makes concept structures, as used in this workshop, unique is that they define behaviors or actions related to the concept. Concept structures are often surprisingly consistent from area to area. For example, the actions involved with "Managing Office Records" could be receiving, sorting, filing, and retrieving. Remarkably similar actions are involved in handling replacement parts in an auto repair facility. Often concepts from one area can be slightly modified to become appropriate in an area heretofore considered unrelated.

Workshop Organization

Each participant in these workshops is highly likely to be employed by one of the school corporation and is fully qualified and certified by the State of Indiana to teach in his/her specialty. Therefore, the workshop sessions will focus only on the strategies to analyze, organize, and evaluate potential content for Tech Prep programs in the State of Indiana.

There are four sessions designed to address the major tasks needed to produce instructional materials that:

- are interdisciplinary by design,
- are based on workplace requirements,
- relate practical applications to their theoretical base,
- progress from concrete to abstract levels.

The first session introduces concept structures and is designed to use information from a variety of sources, as well as the knowledge and experience of the participants, to define the concepts that are related to the several program areas in local or regional Tech Prep programs.

The second session refines and then uses the concept structures to identify and partition teachable content to the several disciplines included in the Tech Prep delivery system.

The third workshop will focus on developing teaching materials to facilitate the delivery of the content identified in the first workshop and partitioned in the second workshop.

The final workshop will address measurement and evaluation issues based on the unique requirements of Tech Prep programs

Assumptions About Participants

Participants in these workshops would not be in attendance if they were not properly educated, certified, and knowledgeable about the day-to-day conduct of their teaching duties. In addition it is assumed that, by their attendance, participants are:

- Committed to meeting the needs of students in Tech Prep programs,
- Desirous of adding to their store of knowledge about the efficient delivery of content in new contexts,
- Willing to cooperate and share their knowledge and experience with others in the development of new and innovative learning materials.

Intended Outcome

The workshop materials have been designed to make it possible for Tech Prep professionals to analyze, integrate, and share a variety of concepts in such a way that they have created a *living* document that can *continuously evolve* for the betterment of the young learners who are enrolled in their classes.

Participants will all find different uses and applications for the materials developed in these workshops. It is hoped that all involved in these workshops will continuously improve these materials as new information and classroom experience become available.

WORKSHOP 1

CURRICULUM DEVELOPMENT

By

Alan R. Suess
Professor of Industrial Technology
Purdue University

Abstract

This is the first of the four staff development workshops described in Division III, Overview. This workshop introduces the use of concept structures as a curriculum building tool. Primarily of interest to those responsible for staff development.

Indiana Tech Prep Training Manual: Division III
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

WORKSHOP 1: OVERVIEW
CURRICULUM DEVELOPMENT WORKSHOP

This workshop begins the introduction to a method of analyzing educational content that may, at first, seem confusing and unnecessary. You will be asked to identify more content than can be covered in any reasonable course, or series of courses. You will be asked to identify subconcepts associated with the core concept that may be outside the traditional realm of the core subject.

Why is this approach either necessary or appropriate? Full analysis of the concepts associated with any academic area are necessary to establish the true (vis-a-vis traditional) content. Without a complete analysis of the content it is impossible to defend criticism of either the inclusion or exclusion of any particular content in a course or curriculum.

Will the approach work? The answer is an unqualified yes! For twenty years in a variety of circumstances the approach has simplified, unified, and organized instruction in a variety of programs. Student success increased in a vocational building trades program when the content was reorganized around very few concepts. The developers were able to organize the multi-year program around the fact that all building activities can be organized within only three sets of dichotomous concepts. Building projects are either new construction or remodeling, the work is performed on either interiors or exteriors, and the actual construction is either "rough" or finish. When these concepts were shared with the industrial advisory board for the program, several contractors used the concepts to reorganize their bidding methods. Civil engineers in an emerging nation, with no teacher education background, streamlined a postsecondary highway construction technology program by identifying the concepts associated with surveying and constructing highways. An art teacher was able to effect substantial changes by analyzing content based on two- and three-dimensional forms of artistic expression.

Will the analysis endure? No one can be certain what the future will bring, but experience has shown that carefully prepared concept structures are not adversely influenced by technological change. Well developed analyses of "office" occupations have not been radically altered by the advent of computers for bookkeeping and word processing. The construction program analysis was completed before the advent of solvent-welded plastic pipe was common. Because the concept analysis was based piping potable water and sanitary systems, the change in the piping material had no influence on the instruction other than the three minute demonstration of how to make the fitting watertight.

WORKSHOP 1: TRAINER MATERIAL
CURRICULUM DEVELOPMENT

*** WORKSHOP OBJECTIVES AND PRODUCT

** Workshop Objectives
As a result of participation in this workshop, Tech Prep professionals will be able to:

- Use DACUM studies and other curriculum development materials to identify general and specific content for Tech Prep classes.
- Merge content from several curriculum analyses into concept structures.

** Materials Needed for Workshop

- As soon as the participants are known, request that they bring appropriate Tech Prep curriculum materials to the workshop
- Six (6) new pencils (matches or toothpicks) for *each* group

** Workshop Product -Several interdisciplinary concept structures

*** WORKSHOP INTRODUCTION

** Ask the participants to read the Workshop Overview in the manual prior to your presentation of this workshop.

** Summarize the overview emphasizing

- Organization of the workshop - four sessions which will continuously develop and refine Tech Prep teaching materials
    - Session 1 - Curriculum development
    - Session 2 - Identifying and allocating content
    - Session 3 - Developing teaching materials
    - Session 4 - Evaluating student performance
- Reliance on participants as educational professionals to use their existing skills and knowledge in the preparation of Tech Prep instructional materials

** Psychological Set

- Psychological set is a factor in many human endeavors. The following introductory activates are designed to demonstrate the consequences of using set inducing words when attempting to solve problems. Use this introduction to emphasize the influence of set in curriculum development among the various subject matter specialists.
- Divide the workshop participants into small groups striving to create groups with diverse professional backgrounds
    - TASK 1: Ask the groups to use the paper and pencils available to DRAW a figure with *only* four (4) equilateral triangles using only six (equal length) lines Time limit: 3 minutes
    - This task is commonly included in introductory psychology textbooks, so several participants may be aware of the solution. Request that such individuals not reveal the solution to other group members
        - The correct solution is a pyramid with a triangular base
        - Several instant, but incorrect, solutions will probably arise. These include:
        - A square with diagonals. Note that the diagonals are 1.414x the length of the square sides and not an equilateral triangle
        - A "star of David" figure of overlapping triangles. Note that the figure creates more than four triangles
    - Stop the task at precisely the time limit
    - TASK 2: Distribute six (6) new pencils (or toothpicks, wooden matches, or other equal length objects) to the groups and ask them to *CONSTRUCT* a figure with only four (4) equilateral triangles using the six pencils provided. Time limit: 3 minutes
    - Typically the term CONSTRUCT frees the participants of the two dimensional "set" that the word DRAW creates

- Briefly discuss "set" in curriculum and instruction
    - Set varies by academic area
    - Set varies by region and culture - The British are concerned with learning materials and computer- aided learning while U.S. professionals prepare teaching materials and use CAI (computer- aided instruction) in their classes

** "Set" As A Factor in Curriculum Development

- Review the instructional bases of Tech Prep with the participants
    - Interdisciplinary
    - Based on workplace performance requirements
    - Applications are related to their theoretical base
    - Instruction progresses from concrete to abstract
- Encourage workshop participants to briefly describe the curriculum development procedures common to their individual disciplines
- Compare the curriculum development procedures identified to the requirements of a Tech Prep program
- Emphasize unique requirements of Tech Prep and the need for interdisciplinary coordination

*** CURRICULUM DEVELOPMENT FOR TECH PREP

** Ask participants to read the Curriculum Development Overview before presenting materials in this section

** Tech Prep programs base instruction on workplace performance requirements

- Traditional workplace approach - Task Analysis
    - Advantages
        - Specialists identify specific tasks for specific occupations
        - Analysis defines content sequence

- Disadvantages
    - Analysis becomes obsolete with minor changes in technology
    - Analysis focused on a single occupation -does not attempt to provide interdisciplinary instruction

- Emerging approach - DACUM (Develop **A** Curricul**UM**) - See DACUM Attachments at the end of this Curriculum Development Workshop
    - Key benefits
        - Based on inputs from several practitioners (not managers) in business or industry
        - Developed by occupational title or position
    - Outcomes
        - Job descriptions defined and refined
        - Individual tasks defined
        - Content often sequenced by category
    - Advantages
        - Based on local occupational information
        - Previous analyses from other geographic areas available thorough the Center of Education and Training at Ohio State University
        - Creates sense of "ownership" within the community
        - Technological change has less impact on total program

  - Disadvantages
    - Local occupational information may not reflect national or regional practice
    - Information most likely to emphasize only the content focus of the participants
    - Information is compiled by persons with a limited frame-of-reference of adolescents as learners
    - Requires a skilled facilitator to maximize the quality of occupational inputs
    - Best suited to technical content
    - Focused on a single occupation

- ** Tech Prep programs must be educationally efficient
  - Content common to several workplace environments must be identified to avoid duplication
  - Content must be focus on theoretical bases to minimize the impact of technical change
  - Content must be organized to insure initial instruction that focuses on concrete applications

- ** Tech Prep must develop interdisciplinary instruction
  - DACUM or other procedures identify work tasks from business and industry
  - Professional staff must translate the tasks from many occupations into practical and efficient course content
  - Determining the *concept structure* of the occupational information can create interdisciplinary instructional content

*** DEVELOPING INTERDISCIPLINARY CONCEPT STRUCTURES

** Concept defined

- In general, a *concept* is an idea or thought that forms a similar mental image in the minds of many people. For most people the concept "TABLE" will evoke a similar description. While there are endless variations in actual tables, most people will differentiate tables from other objects regardless of their height, leg design, and size.
- In a curriculum sense, a concept is a general outcome or procedure composed of several subconcepts
- The concept RECYCLING is composed of at least the following first-order subconcepts
  - Reusing - sterilizing and refilling bottles
  - Repairing - restoring to use
  - Reprocessing - melting old cans to manufacture new cans
  - Disposing - discarding materials with no recycling potential
- Each first-order subconcept can have several levels of subconcepts
  - Reusing (First-order subconcept)
    - Returning (Second-order subconcept)
      - Collecting (Third-order subconcept)
      - Transporting
      - Receiving
      - Storing
    - Inspecting
      - Sorting
      - Classifying
      - Discarding
    - Reconditioning
      - Cleaning
      - Repairing
      - Packaging
      - Storing
    - Redistributing
      - Exchanging
      - Leasing/renting
      - Selling

** Rules for developing Concept Structures

- Rule 1: The content must have a conceptual base
- Rule 2: Subconcepts must be mutually exclusive from each other
- Rule 3: Each subconcept must be totally inclusive of its possible activities
- Rule 4: Subconcepts must designate actions and be logically arranged in sequence

** Designing Concept Structures

- A properly designed Concept Structure has the potential to identify content appropriate to several disciplines
- Example of a Concept Structure based on communications requirements identified in several office occupations
- Key concept - **Communicating at Work**
- Subconcepts - **Listening, Speaking, Writing, Reading**
  - **Listening**
    - Recognizing verbal requests
    - Interpreting verbal requests
    - Summarizing verbal requests
    - Organizing information about requests
    - Acting on requests
  - **Speaking**
    - Gathering information
    - Organizing information
    - Expressing thoughts
    - Using oral language
      - Establishing person
      - Establishing tense
      - Determining correct pronunciation
  - **Writing**
    - Gathering information
      - Using manual methods
      - Using computer retrieval methods
    - Organizing information
    - Expressing thoughts
    - Using written language
      - Determining person
      - Determining tense
      - Verifying spelling
  - **Reading**
    - Recognizing symbols
      - Recognizing language symbols
      - Recognizing graphic symbols
    - Interpreting symbols
      - Interpreting language symbols
      - Interpreting graphic symbols
    - Analyzing symbols
      - Analyzing language symbols
      - Analyzing graphic symbols

** Testing the Concept Structure

- Is "Communicating at Work" a valid concept?
- Are Listening, Speaking, Writing, and Reading appropriate subconcepts of Communicating at Work?
    - Should any subconcepts be added?
    - Should any subconcepts be deleted?
- Are the subconcepts mutually exclusive?
- Is each subconcept totally inclusive?
- Do concepts at all levels designate actions?
- Are concepts at all levels arranged in a logical sequence?
- Are all subconcepts divided into at least two behaviors? If not, is the subdivision valid or misnamed?

*** CURRICULUM DEVELOPMENT WORKSHOP ACTIVITY

** Request that participants bring existing local or regional Tech Prep curriculum/course information, DACUM studies, etc. for use in the workshop.

** Identify major Tech Prep content related to local, regional or national needs. This content may be based on already identified needs, or those identified by the workshop participants. Assist participants in establishing Concept Structures using the principles taught in this workshop to organize these concepts into outlines that meet all of the criteria established in the TESTING THE CONCEPT section

** Continuously emphasize that the concept structure should be totally inclusive in each category and that each category must be mutually exclusive of other categories. This is the easiest way to insure that the interdisciplinary nature of the concept will be identified.

** Continuously emphasize that the concept structure must be developed independent of predetermined objectives. A properly developed concept structure will make it possible to determine appropriate objectives based on the content structure determined -- not limited by selecting content to meet predetermined (and often narrow) objectives.

** Reserve sufficient time for the individual groups to report on their activities and for large group discussion of the results of the development activity.

** Request that participants bring their Concept Structures and other relevant curriculum materials to the Identifying Tech Prep Content Workshop.

WORKSHOP 1: TRAINEE MATERIAL
CURRICULUM DEVELOPMENT

*** INSTRUCTIONAL BASIS FOR TECH PREP

- ** Interdisciplinary
- ** Based on workplace performance
- ** Applications are related to their theoretical base
- ** Instruction progresses from concrete to abstract

*** DEVELOPING CONCEPT STRUCTURES

** Concept Defined

A *concept* is an idea or thought that forms a similar mental image in the minds of many people.

TABLE, BASEBALL, BABY

What images do these concepts bring to mind?

** Concept, in a curriculum sense, can be defined as a

GENERAL OUTCOME OR PROCEDURE DEFINED BY ITS SUBCONCEPTS

** If RECYCLING was part of a curriculum, it would be defined by *at least* the following subconcepts

REUSING - REPAIRING - REPROCESSING - DISPOSING

** These four subconcepts are first order elements of the concept RECYCLING. Further subdivision is possible. For example, REUSING has lower order subconcepts that include *at least* the following:

- Reusing (First-order subconcept)
  - Returning (Second-order subconcept)
    - Collecting (Third-order subconcept)
    - Transporting
    - Receiving
    - Storing
  - Inspecting
    - Sorting
    - Classifying
    - Discarding
  - Reconditioning
    - Cleaning
    - Repairing
    - Packaging
    - Storing
  - Redistributing
    - Exchanging
    - Leasing/renting
    - Selling

*** RULES FOR DEVELOPING CONCEPT STRUCTURES

** Rule 1: The content must have a conceptual base

** Rule 2: Subconcepts must be mutually exclusive from each other

** Rule 3: Each subconcept must be totally inclusive of its possible activities

** Rule 4: Subconcepts must designate actions *an*d be logically arranged in sequence/

*** EXAMPLE OF AN ABBREVIATED CONCEPT STRUCTURE

Conceptual Analysis of "Communicating at Work"

- ** Listening
  - * Recognizing verbal requests
  - * Interpreting verbal requests
  - * Summarizing verbal requests
  - * Organizing information about requests
  - * Acting on requests
- ** Speaking
  - * Gathering information
  - * Organizing information
  - * Expressing thoughts
  - * Using oral language
    - * Establishing person
    - * Establishing tense
    - * Determining correct pronunciation
- ** Writing
  - * Gathering information
    - * Using manual methods
    - * Using computer retrieval methods
  - * Organizing information
  - * Expressing thoughts
  - * Using written language
    - * Determining person
    - * Determining tense
    - * Verifying spelling
- ** Reading
  - * Recognizing symbols
    - * Recognizing language symbols
    - * Recognizing graphic symbols
  - * Interpreting symbols
    - * Interpreting language symbols
    - * Interpreting graphic symbols
  - * Analyzing symbols
    - * Analyzing language symbols
    - * Analyzing graphic symbols

*** TESTING THE CONCEPT STRUCTURE

** Is "Communicating at Work" a valid concept?

** Are Listening, Speaking, Writing, and Reading appropriate subconcepts of Communicating at Work?

    * Should any subconcepts be added?

    * Should any subconcepts be deleted?

** Are the subconcepts mutually exclusive?

** Is each subconcept totally inclusive?

** Do concepts at all levels designate actions?

** Are concepts at all levels arranged in a logical sequence?

** Are all subconcepts divided into at least two behaviors? If not, is the subdivision valid or misnamed?

*** DACUM ANALYSIS SHEETS

For those unfamiliar with a DACUM analysis, three analyses prepared by the Mishawaka Tech Prep Demonstration Cite have been included. Analysis sheets include:

HEALTH OCCUPATIONS TECHNICIAN: A trained individual who serves in the health care area in any one of a multitude of specific careers. December 8, 1988

SCIENCE/ENGINEERING OCCUPATIONS: A trained individual in any one of many applied science/engineering occupations. January 31, 1990

TECHNOLOGY OCCUPATIONS: A trained individual in any one of many business technology occupations. January 31, 1990

IVY TECH - NORTHCENTRAL
SCHOOL CITY MISHAWAKA
Tech Prep Curriculum - December 8, 1988
HEALTH OCCUPATIONS TECHNICIAN:
a trained individual who serves in the health care
area in any one of a multitude of specific careers

Ruth Armstrong, MA	Medical Assistant Instructor - Medical/Administrative Prog	Ivy Tech
Teresa Ganser, MS RRA	Medical Records Consultant	
Liz Gawlik, RN	Staff Development	Regency Place
Elie Jaquish, CRTT/LPN		Norrell Health Care, INC
Carol Kazmierczak	Physical Therapy Director	Healthwin Hospital
Agatha Mathewson, RN	Ivy Tech - Associate of Science in Nursing	
Joyce Peterson-Miler	Medical Technologist	South Bend Medical Foundation
Barbara Pasionek	Dental Assisting Program	IUSB Dental Auxiliary Education
Mary Youngs	Medical Technologist	South Bend Medical Foundation
Cheryl Hodges-Stilson MA,CCC,SLD	Director-Communication Department Speech/language pathology	Healthwin Hospital

DACUM Facilitator: Timothy D. Nolan
DACUM Coordinator/Recorder: Diane K. Chaddock

A Develop and display professionalism	A-1 Demonstrate professional courtesy	A-2 Present a positive attitude	A-3 Create and maintain professional atmosphere and environment	A-4 Maintain personal hygiene and dress code	A-5 Demonstrate work ethics, i.e. punctuality, attendance, etc.	A-6 Organize and manage time effectively	A-7 Maintain composure (e.g. coping with dying or angry reactions)	A-8 Manage stress effectively	A-9 Exercise professional assertiveness	A-10 Participate in continuing education			
B Adhere to legal/ethical standards	B-1 Maintain registration/certification/licensure	B-2 Abide by state and federal laws and regulations	B-3 Follow established policies and procedures	B-4 Practice within legal boundaries	B-5 Adhere to professional code of ethics	B-6 Maintain and protect patient confidentiality	B-7 Complete incident/unusual occurrence reports						
C Risk management	1C Practice medical asepsis	1C-1 Follow universal precautions e.g. infection control	1C-2 Differentiate medical and surgical asepsis	1C-3 Practice handwashing techniques	1C-4 Update personal immunization and screening tests								
	2C Follow safety guidelines	2C-1 Adhere to OSHA standards	2C-2 Follow established safety standards	2C-3 Utilize good body mechanics	2C-4 Transport/transfer patients safely	2C-5 Maintain environmental safety							
	3C Prepare to react to emergency situations	3C-1 Maintain CPR certification	3C-2 Perform first aid skills	3C-3 Recognize medical emergencies	3C-4 Follow established emergency procedures, e.g. fire and disaster drills	3C-5 Operate safety equipment							
D Maintain quality assurance	D-1 Define and update quality assurance standards	D-2 Monitor quality control	D-3 Assess and verify accuracy of operations*	D-4 Document actual findings/results	D-5 Report and recommend follow up								
E Provide for direct patient care	E-1 Assure patient identification	E-2 Verify orders	E-3 Identify contraindications for patient care based on conditions	E-4 Recognize patient limitations and strengths	E-5 Establish priorities for safe patient care	E-6 Provide emotional support	E-7 Position patient for procedure, comfort or therapy	E-8 Maintain the integrity of patient support devices	E-9 Collect patient specimens	E-10 Perform physical, emotional assessment as needed	E-11 Measure vital signs, height, weight		
F Communication skills (verbal and nonverbal)	F-1 Listen effectively	F-2 Demonstrate empathy	F-3 Build rapport with patient and significant others	F-4 Interpret non-verbal communication	F-5 Interact appropriately with other health care workers	F-6 Follow established lines of communication	F-7 Use accurate medical terminology	F-8 Modify terminology to level of understanding	F-9 Adapt to geographical language/cultural requirements	F-10 Write legibly and effectively utilizing correct grammar, punctuation, spelling	F-11 Utilize communication equipment and methods	F-12 Demonstrate and/or explain procedures according to learner needs	F-13 Inform patient of institutional policies
G Computer/technology usage	G-1 Define basic computer technology	G-2 Identify computer components	G-3 Demonstrate basic skills in computer operations	G-4 Discuss general applications of computers	G-5 Apply principle of computer use to health care	G-6 Operate instrumentation and equipment	G-7 Maintain instrumentation and equipment	G-8 Interpret and report results	G-9 Recognize malfunctions/abnormalities and provide appropriate follow-up				
H Primary/basic competencies	H-1 Demonstrate the ability to write and speak clearly	H-2 Interpret/apply written material	H-3 Perform calculations	H-4 Relate basic anatomy and physiology principles to health care setting	H-5 Recognize signs and symptoms of disorders (e.g. diseases, injuries, behaviors)	H-6 Relate basic principles of chemistry, microbiology, physics to health care setting	H-7 Recognize and use basic pharmacology concepts	H-8 Identify the role of nutrition in health and disease	H-9 Describe different methods of health care payments	H-10 Demonstrate basic job seeking skills (e.g. resume, interview applications)	H-11 Recognize various job opportunities within the health care system	H-12 Operate keyboard	

* D-3
—Analyze procedures regarding patient charges
—Perform routine checks on equipment and report malfunctions
—Maintain inventories and supplies
—Record patient data and procedures
—Maintain operational and patient files

BEST COPY AVAILABLE

A. Professional Personal Qualities	A-1 Practice Ethics	A-2 Recognize Company Operations and Organizational Chain of Command	A-3 Recognize Job Role and Importance	A-4 Set Career Goals	A-5 Participate in Continuing Education	A-6 Demonstrate Human Relations	A-7 Demonstrate a Sensitivity to Company Policy	A-8 Project Professional Image	A-9 Demonstrate Problem Solving Skills
B. Math Skills	B-1 Operate Calculator & Perform Manual Calculations	B-2 Interpret Word Problems	B-3 Convert Fractions to Decimals	B-4 Perform Unit Conversions	B-5 Relate Algebra, Geometry and Trigonometry Concepts	B-6 Check Work for Accuracy			
	B-7 Perform Error Analysis	B-8 Relate Basic Statistics	B-9 Compare Interpret Data	B-10 Demonstrate Use of Metrics Conversion Process	B-11 Plot and Interpret Charts and Graphs	B-12 Identify Role of Bookkeeping in Industry	B-13 Perform Data Collection and Analysis		
C. Computer Literacy	C-1 Demonstrate Keyboard/Typing Skills	C-2 Use and Recognize Computer Terminology	C-3 Present Spreadsheets	C-4 Recognize CAD/CAM Applications	C-5 Identify and Use Basic Operation Systems and Program Sources	C-6 Demonstrate Hands-on Experience with Software (Lotus)	C-7 Demonstrate Basic Knowledge in Computer	C-8 Write Basic Functional Programs	
D. Occupational Safety	D-1 Identify and Use Safety Regulatory Manuals/Sources	D-2 Operate Hand Tools Safely	D-3 Demonstrate Minimal First Aid Skills	D-4 Follow Procedures for Disaster Emergencies	D-5 Apply General Shop and Lab Safety Rules	D-6 Operate Machinery Safely	D-7 Read and Interpret MSDS		
E. Communication Skills	E-1 Interpret and Use Technical Vocabulary	E-2 Write Process Manuals	E-3 Write Test Reports	E-4 Present Information Orally	E-5 Give and Receive Instructions and Directions	E-6 Summarize Information	E-7 Read and Interpret Information	E-8 Demonstrate Effective Interpersonal Communication Skills	E-9 Participate as a Team Player
F. Lab and Testing Skills	F-1 Analyze Cause and Effect	F-2 Understand & Apply Basic Chemistry Concepts	F-3 Understand & Apply Basic Physics Concepts	F-4 Understand & Apply Basic Electrical/Electronic Concepts	F-5 Set-up Lab Tests	F-7 Report Test Data/Information			
G. Manufacturing Skills	G-1 Operate Equipment (eg CNC)	G-2 Apply Basic Electrical/Electronic Concepts	G-3 Apply Basic Mechanical Concepts	G-4 Demonstrate Understanding Process Techniques (eg. Welding, Molding, Machining, etc.)	G-5 Read and Interpret Mechanical and Electrical Drawings	G-6 Understand Quality Control Concepts			
H. Basic Sciences	H-1 Electronic and Electrical Applications	H-2 Organizational Skills and Problems Solving	H-3 Electrical Drawing Course	H-4 Mechanical Drawing Course	H-5 Materials Course	H-6 Applied Chemistry and Applied Physics Courses			

IVY TECH-NORTHCENTRAL
SCHOOL CITY MISHAWAKA
Tech Prep Curriculum - January 31, 1990
SCIENCE/ENGINEERING OCCUPATIONS
a trained individual in any one of
many applied science/engineering occupations

DACUM MEMBERS

Phillip Evans Miller Supply	**Jerry Wroblewski** Raco Inc
Paul McBride	**Roy Strader** Instructor Indiana Vocational Technical College
Mark Jamison Gurley-Leep Buick, Inc	
Tim Kinney Bendix Engine Controls	**David Rhachard** Bendix Wheel and Brakes Division
Gene Ralstn Wells Electronics, Inc	**Jim Putt** Wells Electronics
Oran Johnson, Bendix Wheel and Brakes Division	**Timothy D. Nolan** Dacum Facilitator
Al Lang Bendix Engine Controls	**Diane K. Chaddock** Dacum Coordinator/Recorder

BEST COPY AVAILABLE

A. Communication Skills	A-1 Practice Active Listening Skills	A-2 Demonstrate Effective Telephone Skills	A-3 Demonstrate the Ability to Ask Questions	A-4 Use Proper Grammar	A-5 Use Proper Diction	A-6 Demonstrate Professional Courtesy	A-7 Speak and Write Ideas Grammatically Correct and in a Concise Manner	A-8 Articulate Ideas and Concepts	A-9 Accept Constructive Criticism	A-10 Demonstrate Positive Non-Verbal Skills
B. Organizational Skills	B-1 Analyze Problems	B-2 Research Problems and Resources	B-3 Solve Problems	B-4 Complete Tasks Thoroughly (follow-up)	B-5 Organize Work Area	B-6 Manage Time Effectively				
	B-7 Demonstrate Good Study Skills	B-8 Display Self-Confidence	B-9 Participate as a Team Member	B-10 Balance Personal and Business Priorities	B-11 Demonstrate Ability to Prioritize Job Responsibilities	B-12 Anticipate Future Needs (projections)				
C. Technical Skills	C-1 Read and Comprehend Information	C-2 Demonstrate the Ability to Apply Mathematical Concepts	C-3 Demonstrate Computer Literacy	C-4 Operate Office Machines and Equipment	C-5 Demonstrate Keyboarding/Typing Skills	C-6 Operate a Calculator	C-7 Understand and Use Filing System			
	C-8 Write Legibly	C-9 Spell Correctly	C-10 Formal Business Communications	C-11 Perform and Practice Proof Reading Skills	C-12 Apply and Use Basic Business Principles and Terminology	C-13 Apply and Use Basic Accounting Principles and Terminology				
D. Personal and Professional Qualities	D-1 Project Professional Image and Personal Hygiene	D-2 Demonstrate Employability Skills (interviewing, application, resume)	D-3 Demonstrate Punctuality and Honesty	D-4 Maintain Client/Customer/Company Confidentiality	D-5 Practice Business Etiquette	D-6 Demonstrate Self-Discipline	D-7 Complete Assignments and Tasks	D-8 Display a Productive and Achievement Oriented Attitude		
	D-9 Demonstrate a Willingness to Learn	D-10 Demonstrate Creativity and Adaptability	D-11 Demonstrate Initiative and Assertiveness	D-12 Display Openmindedness and Flexibility	D-13 Participate Cooperatively with Co-workers and Supervisors	D-14 Demonstrate the Willingness to Help				
E. Company Operations	E-1 Set Realistic Career Goals	E-2 Research Job Opportunities	E-3 Prepare for Job Interview	E-4 Recognize Organizational Structure and Interdependence of Functions	E-5 Project Company Image Constantly	E-6 Follow Company Policy and Procedures	E-7 Understand the Importance of Legal Aspects of the Job Function	E-8 Participate as a Team Member (group dynamics)	E-9 Display Sensitivity to Company Politics	

IVY TECH-NORTHCENTRAL
SCHOOL CITY MISHAWAKA
Tech Prep Curriculum - January 31, 1990
TECHNOLOGY OCCUPATIONS
a trained individual in any one of
many business technology occupations

DACUM MEMBERS

Mrs Margaret Andrysiak Consultant Valley American Bank	**Bonnie Luczyk** 1st Source Bank
Nancy King Trustcorp Bank	**Kay Rybicki** Business Instructor Indiana Vocational Technical College
Judy Heritz Crowe Chizek & Co. CPA	**Jan Fye** Department Chair Management Studies Indiana Vocational Technical College
Karen Wolf	**Timothy D. Nolan** Dacum Facilitator
Gary Barnard Endata	**Diane K. Chaddock** Dacum Coordinator/Recorder
Bob Roden Consultant	

BEST COPY AVAILABLE

WORKSHOP 2

IDENTIFYING TECH PREP CONTENT

By

Alan R. Suess
Professor of Industrial Technology
Purdue University

Abstract

This is the second of the four staff development workshops described in Division III, Overview. This workshop uses concept structures to identify course content and level. Primarily of interest to those responsible for staff development.

Indiana Tech Prep Training Manual: Division III
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

WORKSHOP 2: OVERVIEW
IDENTIFYING TECH PREP CONTENT WORKSHOP

Unless the participants in the first workshop were exceptional, your initial concept structures had several shortcomings. Hopefully, both time and curiosity have had an influence on your judgment. Also, the practice effect of your first efforts should have started to internalize your understanding of the process. The first part of this workshop session is devoted to fine tuning the concept structures.

No workshop developer can possibly predict the outcomes of so highly variable activity as developing concept structures. What can be predicted is that when well done, the analysis defined much more content than can or should be taught. Once the concepts have been refined it is time for a series of professional decisions about scope, sequence, and approach to teaching the identified content.

These serious decisions cannot be made by formula. The level of instruction, the characteristics of the students, resources available, and a variety of other factors require the professional judgment of teachers and administrators who know the exact circumstances of the local program. There are, however, some general concerns about responsibility and accountability that must be addressed.

Properly prepared concept structures will identify content across several traditional academic areas. Did any "flashing red lights" go off when you reviewed the Communicating at Work structure during the first workshop session? Who would be best qualified to teach the reading of graphic symbols concepts? Could it be the same professionals who are teaching the reading of language symbols? Could it be teachers from other disciplines?

These and related decisions may require careful negotiation and formal documentation if local school board policy or collective bargaining agreements mandate such actions. In other cases, a handshake agreement may be all that is required. What is important is that the concept structure can provide a neutral analysis of potential content allocation unfettered by mind set or local tradition.

WORKSHOP 2: TRAINER MATERIAL
IDENTIFYING TECH PREP CONTENT

*** WORKSHOP OBJECTIVES AND PRODUCT

- ** Workshop Objectives
  As a result of participation in this workshop, Tech Prep professionals will be able to:
    - * Partition Concept Structure content into appropriate academic disciplines
    - * Partition Concept Structure content into appropriate courses
- ** Materials Needed for Workshop
    - * Previously prepared Concept Structures
    - * DACUM charts or other task/occupation studies
- ** Workshop Product
    - * Recommendations for content assignment by academic area
    - * Recommendations for course content within academic areas

*** WORKSHOP INTRODUCTION

- ** Ask the participants to read the Identifying Tech Prep Content Overview prior to your presentation of this workshop

*** REVIEW INSTRUCTIONAL BASES OF TECH PREP

- ** Interdisciplinary
- ** Based on workplace performance requirements
- ** Applications are related to their theoretical base
- ** Instruction progresses from concrete to abstract

*** DEVELOPING A CONCEPT STRUCTURE -- A REVIEW

- ** Properly prepared Concept Structures
    - * List subconcepts so that:
        - * Each subconcept is totally inclusive
        - * Content is logically ordered within each subconcept
        - * All subconcepts are mutually exclusive
    - * Disregard teaching order/level
    - * Are stated as action verbs at every concept level
    - * Do not reflect predetermined objectives
        - * Subconcepts are already stated as action verbs
        - * At course development stage, desired outcomes about the defined actions become the objectives
    - * Identify *all* subconcepts related to the main concept
        - * Insures comprehensive analysis of the concept
        - * Allows course developer to identify primary content for any given level of instruction about the concept

** Examples of a Concept Structure
Follow the analysis using the information in your Trainee's Manual. NOTE: Concept Structure is reproduced on page 3.

- The *Major Concept* being evaluated is RECYCLING.

  RECYCLING includes the several *actions* necessary to extend the useful life of materials following their initial use. The exact recycling procedures will vary with the form of the material and the manufacturing design.

- REUSING, REPAIRING, REPROCESSING, and DISPOSING are *first-order subconcepts*. Each represents a *mutually exclusive action* that is, in itself, a form of RECYCLING

- INSPECTING is an important *action* in effectively REUSING of certain materials. No one wants to buy "COKE" in a "PEPSI" bottle, or to buy either drink in a broken bottle. This represents a *second-order subconcept.*

- CLASSIFYING materials to be REUSED is an important *action.* Since it is one of several INSPECTION actions, it is a *third-order subconcept.*

- One CLASSIFYING *action* is CLASSIFYING METALS. Since there are a number of materials to be classified, each is a *fourth-order subconcept.*

- There are a number of ways to subdivide metals into categories. Industrial metals are frequently divided into the *mutually exclusive* categories of ferrous and non-ferrous metals. Therefore the *action* of IDENTIFYING NON-FERROUS METALS is a *fifth-order subconcept.*

- Aluminum alloys are common industrial metals. IDENTIFYING ALUMINUM ALLOYS is one of the *actions* involved with IDENTIFYING NON-FERROUS METALS and is a *sixth-order subconcept.*

Sample Concept Structure

RECYCLING **(Major Concept)**

- 1.0 Reusing **(First-order subconcept)**
  - 1.1 Returning
    - 1.11 Collecting
    - 1.12 Transporting
    - 1.13 Receiving
    - 1.14 Storing
  - 1.2 Inspecting **(Second-order subconcept)**
    - 1.21 Sorting
    - 1.22 Classifying **(Third-order subconcept)**
      - 1.221 Classifying metals **(Fourth-order subconcept)**
        - 1.2211 Identifying ferrous metals
        - 1.2212 Identifying non-ferrous metals **(Fifth-order)**
          - 1.22121 Identifying aluminum alloys
          - 1.22122 Identifying copper alloys **(Sixth-order)**
          - 1.22123 Identifying .....
      - 1.222 Classifying plastics
      - 1.223 Classifying.....
    - 1.23 Discarding
  - 1.3 Reconditioning
    - 1.31 Cleaning
    - 1.32 Repairing
    - 1.33 Packaging
    - 1.34 Storing
  - 1.4 Redistributing
    - 1.41 Exchanging
    - 1.42 Leasing/renting
    - 1.43 Selling
- 2.0 Repairing
  - 2.1 Adjusting
  - 2.2 Replacing subassemblies
  - 2.3 Overhauling
  - 2.4 Remanufacturing
- 3.0 Reprocessing
  - 3.1 Collecting
  - 3.2 Sorting
  - 3.3 Preparing
  - 3.4 Processing
- 4.0 Disposing
  - 4.1 Sorting
  - 4.2 Burying
  - 4.3 Incinerating
  - 4.4 Handling special materials

IDENTIFYING TEACHING CONTENT FROM THE CONCEPT STRUCTURES

- A Concept Structure is intended to identify *more* content than is appropriate or necessary to test the concept itself
    - Identify content that must be taught
    - Identify content that provides introduction to advanced study
    - Identify the content that need not be taught
        - Content already mastered
        - Content inappropriate to the existing level of instruction
    - Most units of instruction will be based on first- or second-order subconcepts
    - Most lessons and activities will derived from third-order or lower subconcepts
- Issues to address in assigning content to academic disciplines
    - What is the objective of the instruction?
        - At what level will the content be taught?
            - Introductory level?
            - Advanced?
    - What is the intended outcome for the concept being taught?
        - Does the action verb indicating the concept adequately describe the desired behavioral objective?
        - What type of behavioral change is desired?
    - Which academic area(s) will be responsible for the primary instruction?
        - Are all subconcepts appropriate to a given academic area?
            - Does the faculty possess the background to present the concept?
            - Does the facility have the needed equipment to present the concept?
        - If the content is to be partitioned across areas, how will the content be coordinated?
    - Which academic area(s) will be responsible for the related instruction?
        - What criteria will be used to assign related content to academic areas?
        - How will the content support the primary instruction?
    - How will accountability for content responsibility be determined?
        - Formally?
        - Informally?
- Partitioning content from the RECYCLING Concept Structure
    - Assigning primary responsibility for the concepts could be
        - Technology for Repairing, Reprocessing and the Processing portions of Reusing
        - Science for Disposing and the Classifying portions of Reusing
    - Related instruction can be broadly distributed across other academic areas
        - Social impacts of recycling
        - Entrepreneurial possibilities of recycling
        - Document preparation relating to recycling

*** Workshop Content Selection Activities

- ** The added information in this Workshop presentation should allow the participants to refine the materials developed during the initial session. Carefully monitor the time that spent modifying the original materials. If at all possible have participants work in their original groups. If this is not possible, form new interdisciplinary groups with mutual interest in the materials developed during the Curriculum Development Workshop

- ** Closely monitor the time spent modifying Concept Structures. At an appropriate time halt the development and conduct a brief discussion of the revised materials.

- ** Request that the groups partition their content into the primary and related instructional areas. Closely monitor the group activity and provide input as required.

- ** Reserve sufficient time for the individual groups to report their activities and for large group discussion of the results of the development activity.

- ** Request that participants bring their Concept Structures and other relevant curriculum materials to the Developing Tech Prep Instructional Materials Workshop.

WORKSHOP 2: TRAINEE MATERIAL
IDENTIFYING TECH PREP CONTENT

*** REVIEW OF INSTRUCTIONAL BASES OF TECH PREP
  ** Interdisciplinary
  ** Based on workplace performance requirements
  ** Applications are related to their theoretical base
  ** Instruction progresses from concrete to abstract

*** DEVELOPING A CONCEPT STRUCTURE -- A REVIEW
  ** Properly Prepared Concept Structures
    * List subconcepts so that
        * Each subconcept is totally inclusive
        * Content is logically ordered within each subconcept
        * All subconcepts are mutually exclusive
      * Disregard teaching order/level
      * Are stated as action verbs at every concept level
      * Do not reflect predetermined objectives
        * Subconcepts are already stated as action verbs
        * At course development stage, desired outcomes about the defined actions become the objectives
      * Identify *all* subconcepts related to the main concept
        * Insures comprehensive analysis of the concept
        * Allows course developer to identify primary content for any given level of instruction about the concept

*** SAMPLE CONCEPT STRUCTURE

RECYCLING **(Major Concept)**

- 1.0 Reusing **(First-order subconcept)**
    - 1.1 Returning
        - 1.11 Collecting
        - 1.12 Transporting
        - 1.13 Receiving
        - 1.14 Storing
    - 1.2 Inspecting **(Second-order subconcept)**
        - 1.21 Sorting
        - 1.22 Classifying **(Third-order subconcept)**
            - 1.221 Classifying metals **(Fourth-order subconcept)**
                - 1.2211 Identifying ferrous metals
                - 1.2212 Identifying non-ferrous metals **(Fifth-order)**
                    - 1.22121 Identifying aluminum alloys
                    - 1.22122 Identifying copper alloys **(Sixth-order)**
                    - 1.22123 Identifying .....
            - 1.222 Classifying plastics
            - 1.223 Classifying.....
        - 1.23 Discarding
    - 1.3 Reconditioning
        - 1.31 Cleaning
        - 1.32 Repairing
        - 1.33 Packaging
        - 1.34 Storing
    - 1.4 Redistributing
        - 1.41 Exchanging
        - 1.42 Leasing/renting
        - 1.43 Selling
- 2.0 Repairing
    - 2.1 Adjusting
    - 2.2 Replacing subassemblies
    - 2.3 Overhauling
    - 2.4 Remanufacturing
- 3.0 Reprocessing
    - 3.1 Collecting
    - 3.2 Sorting
    - 3.3 Preparing
    - 3.4 Processing
- 4.0 Disposing
    - 4.1 Sorting
    - 4.2 Burying
    - 4.3 Incinerating
    - 4.4 Handling special materials

*** IDENTIFYING TEACHING CONTENT FROM THE CONCEPT STRUCTURES

** A Concept Structure is intended to identify *more* content than is appropriate or necessary to test the concept itself

* Identify content that must be taught
* Identify content that provides introduction to advanced study
* Identify the content that need not be taught
    * Content already mastered
    * Content inappropriate to the existing level of instruction
* Most units of instruction will be based on first- or second-order subconcepts
* Most lessons and activities will derived from third-order or lower subconcepts

** Issues to address in assigning content to academic disciplines

* What is the objective of the instruction?
    * At what level will the content be taught?
        * Introductory level?
        * Advanced?
* What is the intended outcome for the concept being taught?
    * Does the action verb indicating the concept adequately describe the desired behavioral objective?
    * What type of behavioral change is desired?
* Which academic area(s) will be responsible for the primary instruction?
    * Are all subconcepts appropriate to a given academic area?
        * Does the faculty possess the background to present the concept?
        * Does the facility have the needed equipment to present the concept?
    * If the content is to be partitioned across areas, how will the content be coordinated?
* Which academic area(s) will be responsible for the related instruction?
    * What criteria will be used to assign related content to academic areas?
    * How will the content support the primary instruction?
* .How will accountability for content responsibility be determined?
    * Formally?
    * Informally?

** Partitioning content from the RECYCLING Concept Structure

* Assigning primary responsibility for the concepts could be
    * Technology for Repairing, Reprocessing and the Processing portions of Reusing
    * Science for Disposing and the Classifying portions of Reusing
* Related instruction can be broadly distributed across other academic areas
    * Social impacts of recycling
    * Entrepreneurial possibilities of recycling
    * Document preparation relating to recycling

WORKSHOP 3

DEVELOPING TECH PREP INSTRUCTIONAL MATERIALS

By

Alan R. Suess
Professor of Industrial Technology
Purdue University

Abstract

This is the third of the four staff development workshops described in Division III, Overview. This workshop uses concept structures to develop both group and individual instructional materials. *Primarily of interest to those responsible for staff development*.

Indiana Tech Prep Training Manual: Division III
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

WORKSHOP 3: OVERVIEW
DEVELOPING TECH PREP INSTRUCTIONAL MATERIALS

A number of years ago the developer of these materials was a guest at an open house. The guests were a remarkably diverse group of people. All were known personally by only the host. However, several guests knew each other and as the evening progressed, social or professional linkages were established through the general conversations of a social evening. As the conversations progressed, the accomplishments of virtually everyone in the room became part of the conversation. No two guests had remotely similar talents or experiences. Each of the conversations evoked comments of envy from others about their travels, activities, or hobbies. Late in the evening the host, a psychologist, turned to me and in a completely serious tone stated: "You know, most human beings are remarkably incompetent in all but a narrow range of talents - isn't that wonderful!"

Think about the psychologist's comment as you progress through this workshop. All of us are really incompetent in all but a narrow range of talents. Regardless of my desire, interest, and special coaching I will never be able to slam dunk a basketball. Is it because I am too small - a physical limitation? Not really! My college roommate had a nearly identical physique and was also 5'-9" tall and he could perform the task with ease.

Developing instructional materials for any class is a matter of judgment. Selecting *appropriate* instructional materials for a class is more a matter of guesswork than anything else. Despite "expert" claims of the superiority of one form of materials over all others, there is precious little hard evidence to support such claims. How do you find that "narrow range of talents" in all human beings - especially your students? Only by developing and delivering content in as diverse a manner as time, talent, resources, and your own imagination will permit.

This "shotgun approach" is the only way to make the learning environment adaptable to all students. The concept structures that you have been creating and modifying can help identify concepts that can be delivered in educationally appropriate ways to students of diverse talents and interests. Remember, that just as two equally honorable humans can see the same milk bottle as either half full or half empty, so can two equally honorable educational professionals perceive the same subconcepts in a concept analysis as appropriate for radically different delivery strategies - isn't that wonderful!

WORKSHOP 3: TRAINER MATERIALS
DEVELOPING TECH PREP INSTRUCTIONAL MATERIALS

- WORKSHOP OBJECTIVES AND PRODUCT
  - Workshop Objectives

    As a result of participation in this workshop, Tech Prep professionals will be able to:
    - Use Concept Structures to design group projects
    - Use Concept Structures to plan a variety of
  - Materials Needed for Workshop
    - Previously prepared Concept Structures
    - Previously prepared content allocation recommendations
    - Other appropriate curriculum and course materials
  - Workshop Product
    - Recommended content and outcomes for group products based on Concept Structures
    - Recommendations for teacher-center instructional materials

- WORKSHOP INTRODUCTION
  - Ask the participants to read the Developing Tech Prep Instructional Materials Overview prior to your presentation of this workshop

- PROBLEMS AND ISSUES IN TRANSLATING CURRICULUM MATERIALS INTO TEACHING MATERIALS
  - The logical/psychological dilemma
    - Most curriculum material has been logically derived by specialists who already know the subject resulting in course content that:
      - Is highly theoretical
      - Is devoid of practical applications
      - Progresses from the specific to the general
    - Most learners enroll in classes because they do *not* already know the subject and need content that:
      - Is related to previously learned content
      - Is initially applied to real life situations
      - Progresses from the general to the specific

- ** The abstract/concrete dilemma
  - Much course material starts with the abstract basis of the content and progresses to the applications
    - Atomic theory is used to explain the behavior of electrical circuits instead of the using the behavior of electrical circuits to explore the theoretical basis of electricity
    - Specific concepts are verbally explained with the assumption that the learner knows the actual basis of the words used
      - A is inversely proportional to B
      - Use the 50:1 ratio gasoline/oil mixture in this engine
  - Curriculums which produce highly regarded graduates use instructional materials which place the learner in the actual situation and then use these concrete situations to teach the theoretical basis of the program
    - Law Schools
      - Case studies
      - Mock Court trials
      - Work experience as a Law Clerk
    - Medical Schools
      - General Practitioners - mandatory one- year internships upon successful completion of medical school
      - Medical Specialists - multiyear Residency programs for fully qualified physicians
        - Residents-in-training first observe skilled specialists perform medical procedures
          - Live procedures
          - Video taped procedures
        - Residents perform basic procedures under direct supervision
        - Residents perform advanced procedures under direct supervision
        - Residents perform entire procedures with immediate after- the-fact evaluations
        - Residents perform entire procedures with delayed evaluations
        - Successful residents pass national "Board Certification" evaluations and enter practice

- ** Assumptions regarding the capabilities of the learner are often incorrect
    - Assuming that because a learner can define, compute, write, etc. he/she *understands and can apply* the information in another context.
    - Use the answer sheet in your manual to determine how well you, as a teacher or administrator, understand some fairly simple concepts when they are presented verbally.
        - **Mathematics**
            - Draw an unscaled graph that represents variables that are directly proportional
            - Draw an unscaled graph that represents variables that are inversely proportional
        - **Science**
            - Two coils of resistance wire are available, one has high resistance per unit length, the other has low resistance per unit length. Which wire would you select for an electrical "hot plate"?
            - What would the heat output be if the voltage to this "hot plate" was doubled?
        - **Language**
          Write the following sentences as they are dictated
            - "Are you two going to the basketball game too?"
            - "It's a fast paced world out there!"
        - **Technology**
            - A shaft has been rough turned to a diameter of 33mm. It must have a final diameter of 30mm. How far must the cutting tool be advanced to cut the final diameter?
            - When one unit of plastic resin is poured into a mold it produces a sheet of plastic of a standard thickness that is 1 meter x 1 meter square. How long would each side of this mold be so that 2 units of resin would produce a sheet of the *same thickness* that was an *exact square* with a 2 square meter area?
    - Your manual includes answers and a brief discussion of to the self-quiz. Use the answer sheet to check your responses. Take heart, very few people will do "well" on this quiz. It is self-scored for good reason
    - Use the self-test to stimulate group discussions of the about the day-to-day conduct of classes and the importance of developing instructional material that takes into account the dilemmas introduced

*** ACCOMMODATING LEARNING STYLES

- ** Tech Prep exists because both educational critics and professionals have been concerned about the limited influence of traditional teaching/learning practices on "average" students

- ** The self-quiz just completed included questions that are "easy" if you have had to graph relationships, build molds, etc. - that is, having used the Tech Prep approach

- ** Beware of "magic elixir" solutions! Snake oil salesmen of legend sold naive people a single bottle of "medicine" to cure all ills

- ** Lacking definitive research evidence of the ultimate superiority of any given teaching/learning method the best approach is to integrate a variety of content delivery strategies into all courses

*** DESIGNING GROUP PROJECTS

- ** Problem solving teams are emerging as a dominant method of solving problems in business and industry - experience in working as a group member must be a high priority in Tech Prep courses

- ** Guidelines for Creating Group Project Teams
    - Teams are assigned by the teacher
    - Teams should be of manageable size - 4-6 per group if class size permits
    - Teams should represent students of all ability levels - for a group of four
        - One high achieving student
        - Two average achieving students
        - One low achieving student

** Identifying Group Project Problems Using Concept Structures

- * Use the Recycling Concept Structure from the Identifying Tech Prep Content Workshop for the following examples -- reproduced on following page

- * Entire high-level subconcepts can become the problem area - the first-order topic of Disposing could be the focus of a group project

- * Because subconcepts at all levels are logically ordered, the next lower level subconcept may be appropriate - the four subconcepts under Returning would give the group project a narrower scope

- * To provide comprehensive coverage of a concept, a number of problem solving teams can each attack one of a series of logically ordered subconcepts - for example the first-order concepts of Reusing, Repairing, Reprocessing, Disposing

- * Because concepts structures are logically ordered within concept levels, and the concepts are in hierarchical order, it is possible to accommodate student ability by assigning low level tasks to the less able and higher level tasks to be more able

Sample Concept Structure

RECYCLING **(Major Concept)**

- 1.0 Reusing **(First-order subconcept)**
  - 1.1 Returning
    - 1.11 Collecting
    - 1.12 Transporting
    - 1.13 Receiving
    - 1.14 Storing
  - 1.2 Inspecting **(Second-order subconcept)**
    - 1.21 Sorting
    - 1.22 Classifying **(Third-order subconcept)**
      - 1.221 Classifying metals **(Fourth-order subconcept)**
        - 1.2211 Identifying ferrous metals
        - 1.2212 Identifying non-ferrous metals **(Fifth-order)**
          - 1.22121 Identifying aluminum alloys
          - 1.22122 Identifying copper alloys **(Sixth-order)**
          - 1.22123 Identifying .....
      - 1.222 Classifying plastics
      - 1.223 Classifying.....
    - 1.23 Discarding
  - 1.3 Reconditioning
    - 1.31 Cleaning
    - 1.32 Repairing
    - 1.33 Packaging
    - 1.34 Storing
  - 1.4 Redistributing
    - 1.41 Exchanging
    - 1.42 Leasing/renting
    - 1.43 Selling
- 2.0 Repairing
  - 2.1 Adjusting
  - 2.2 Replacing subassemblies
  - 2.3 Overhauling
  - 2.4 Remanufacturing
- 3.0 Reprocessing
  - 3.1 Collecting
  - 3.2 Sorting
  - 3.3 Preparing
  - 3.4 Processing
- 4.0 Disposing
  - 4.1 Sorting
  - 4.2 Burying
  - 4.3 Incinerating
  - 4.4 Handling special materials

** Defining Group Project Outcomes
    * Establish the nature of the final group report
        * Written report
        * Working model
        * Other formats
    * Establishing the nature of the final individual report

*** DESIGNING TEACHER-CENTERED MATERIALS

For the same reasons that concept structures provide guidance in the preparation of group projects, they can guide the development and revision of traditional teacher-centered activities such as:

** Developing lectures

** Defining laboratory activities
    * Selecting published activities based on concept structures
    * Preparing activities when necessary

** Developing individuals assignments
    * Selecting topics
    * Assigning topics
    * Establishing report formats
        * Oral reports
        * Written reports
        * Working models
        * Visual or audio media reports

** Using community resources
    * Identifying guest speakers
    * Identifying field trip sites

*** INSTRUCTIONAL MATERIALS DEVELOPMENT WORKSHOP ACTIVITY

** Because most teachers are familiar with traditional instructional materials development, begin with the preparation of a group project assignment based on the available concept structure materials already prepared.

** Closely monitor the time spent developing the group assignment materials. At an appropriate time halt the development and conduct a discussion of the outputs of the several workshop groups.

** In the time remaining, have the groups "tryout" several traditional assignment problems using the concept structures as a guide. Again, monitor progress and reserve time for whole group discussions.

** Request that participants bring *all* of the materials that they have developed in this and previous workshops to the Evaluating Student Performance Workshop.

WORKSHOP 3: TRAINEE MATERIAL
DEVELOPING TECH PREP INSTRUCTIONAL MATERIALS

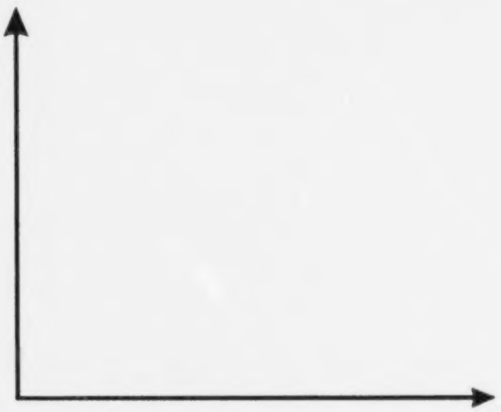
*** PROBLEMS AND ISSUES IN TRANSLATING CURRICULUM MATERIALS INTO TEACHING MATERIALS

- ** The logical/psychological dilemma
  - Curriculums are developed by people who already know the content. Courses that result:
    - Are highly theoretical
    - Are devoid of practical applications
    - Progress from specific to general content
  - Learners need content that:
    - Is related to previously learned content
    - Is initially applied to real life situations
    - Progresses from the general to the specific
- ** The abstract/concrete dilemma
  - Much course material starts with the abstract concepts and then progresses to applications
    - Atomic theory is used to explain electrical circuits instead of the using electrical circuits to explore electrical theory
    - Concepts are verbally explained by teachers
    - Teachers do not use non-verbal means of verifying understanding
  - Highly regarded programs place the learner in actual situation to teach the theoretical basis of the content
    - Law Schools
      - Case studies
      - Mock Court trials
      - Work experience as a Law Clerk
    - Medical Schools
      - General Practitioners - mandatory one- year internships upon successful completion of medical school
      - Medical Specialists - fully qualified physicians learn in a multi-year hands- on training program
- ** Assumptions regarding the capabilities of the learner are often incorrect
  - Assuming that because a learner can define, compute, write, etc. he/she *understands and can apply* the information in another context.

*** DO YOU UNDERSTAND SOME SIMPLE CONCEPTS?

Write your answers in the spaces provided. There is a Self-Check section that follows. Relax and enjoy this not too easy quiz. Only you will know how many simple errors you made!

*Draw a directly proportional curve here



*Draw an inversely proportional curve here

* Which resistance wire would you choose?

___ High resistance per unit length

___ Low resistance per unit length

* What would the heat output be if the voltage doubled?

___ Half the heat output   ___ Double the heat output

___ Same heat output   ___ Four times the heat output

* Write Sentence #1 Here

* Write Sentence #2 Here

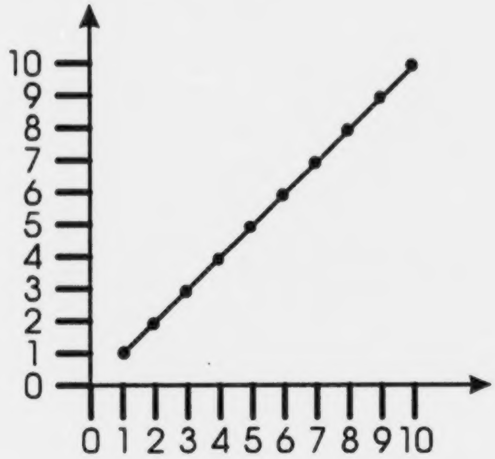
* I would advance the cutting tool ______mm for the final cut.

* I would make the new mold sides ______ meters long.

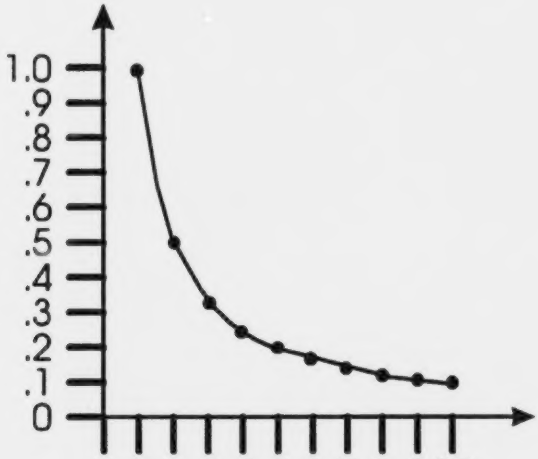
*** ANSWERS TO THE SELF-QUIZ

** **Mathematics**

* *Directly proportional* - Did you draw a straight line from the lower left to the upper right?



* *Inversely proportional* - If you drew a straight line from the upper left to the lower right, your graph is incorrect! Note the correct shape of the curve. What important concept relating to the impact of ever increasing denominator values in inverse relationships is not understood when the concept is not known?



** Science

* Logic often causes people to incorrectly select the high resistance wire for heating elements. Since resistance is inversely proportional to current, *and* the heat generated in a resistance device increases as the square of the current, the low resistance wire is the proper choice.

* Voltage is directly proportional to current. Therefore doubling the voltage will double the current. Since heating increases with the square of the current, the heat output will be four times as great.

** Language

* "Are you two going to the basketball game too?"
    * Did you use the three forms of "to" correctly?

* "It's a fast paced world out there!"
    * Did you *hear* "paced" or "paste"? Did you correctly use the contraction It's, and not the word Its?

** Technology

* Did you recommend advancing the tool 3 mm? If so, the shaft would have a final diameter of 27 mm. Since the workpiece rotates around the lathe centers, it is the radius of the circle that is the major concern. Shortening the radius 1.5 mm reduces the shaft diameter by 3 mm.

* If you recommended a square with 2 meter sides, the area would be 4 square meters and the thickness would be half the standard. The correct solution is a square with 1.414 meter sides. (The square of 1.414 is 2 or the square root of 2 is 1.414)

*** ACCOMMODATING LEARNING STYLES

- ** Tech Prep exists because existing educational approaches are not producing the necessary results
- ** The self-quiz would have been easier if each of you had been required to graph relationships, build molds, etc. - just a good Tech Prep does today
- ** Beware of "magic elixir" solutions!
- ** The best approach to accommodate different learning styles is to integrate a variety of content delivery strategies into all Tech Prep courses

*** DESIGNING GROUP PROJECTS

- ** Problem solving teams are everywhere in the workplace. Experience in working as a group member must be a high priority in Tech Prep courses
- ** Guidelines for Creating Group Project Teams
  - Teams are assigned by the teacher
  - Teams should be of manageable size - 4-6 per group if class size permits
  - Teams should represent students of all ability levels - for a group of four
    - One high achieving student
    - Two average achieving students
    - One low achieving student

*** IDENTIFYING GROUP PROJECT PROBLEMS USING CONCEPT STRUCTURES

** Recycling Concept Structure - from the Identifying Tech Prep Content Workshop

Sample Concept Structure

RECYCLING **(Major Concept)**
- 1.0 Reusing **(First-order subconcept)**
    - 1.1 Returning
        - 1.11 Collecting
        - 1.12 Transporting
        - 1.13 Receiving
        - 1.14 Storing
    - 1.2 Inspecting **(Second-order subconcept)**
        - 1.21 Sorting
        - 1.22 Classifying **(Third-order subconcept)**
            - 1.221 Classifying metals **(Fourth-order subconcept)**
                - 1.2211 Identifying ferrous metals
                - 1.2212 Identifying non-ferrous metals **(Fifth-order)**
                    - 1.22121 Identifying aluminum alloys
                    - 1.22122 Identifying copper alloys **(Sixth-order)**
                    - 1.22123 Identifying .....
            - 1.222 Classifying plastics
            - 1.223 Classifying.....
        - 1.23 Discarding
    - 1.3 Reconditioning
        - 1.31 Cleaning
        - 1.32 Repairing
        - 1.33 Packaging
        - 1.34 Storing
    - 1.4 Redistributing
        - 1.41 Exchanging
        - 1.42 Leasing/renting
        - 1.43 Selling
- 2.0 Repairing
    - 2.1 Adjusting
    - 2.2 Replacing subassemblies
    - 2.3 Overhauling
    - 2.4 Remanufacturing
- 3.0 Reprocessing
    - 3.1 Collecting
    - 3.2 Sorting
    - 3.3 Preparing
    - 3.4 Processing
- 4.0 Disposing
    - 4.1 Sorting
    - 4.2 Burying
    - 4.3 Incinerating
    - 4.4 Handling special materials

** Entire high-level subconcepts can become the problem area - the first-order topic of *Disposing* could be the focus of a group project

** Subconcepts at each level are logically ordered so a portion of the next lower subconcept could be used - the four subconcepts under Returning for example

** Comprehensive coverage of a concept is possible by studying a series of identical level subconcepts - Reusing, Repairing, Reprocessing, Disposing

** Accommodate different learning abilities by assigning lower level subconcepts in a single subconcept area to lower achieving students

*** DEFINING GROUP PROJECT OUTCOMES
** Establish the nature of the final *group* report
  * Written report
  * Working model
  * Other formats
** Establishing the nature of the final *individual* report

*** DESIGNING TEACHER-CENTERED MATERIALS
** Use concept structures for:
  * Developing lectures
  * Defining laboratory activities
    * Selecting published activities based on concept structures
    * Preparing activities when necessary
  * Developing individuals assignments
    * Selecting topics
    * Assigning topics
  * Establishing report formats
    * Oral reports
    * Written reports
    * Working models
    * Visual or audio media reports
  * Using community resources
    * Identifying guest speakers
    * Identifying field trip sites

WORKSHOP 4

EVALUATING TECH PREP STUDENT PERFORMANCE

By

Alan R. Suess
Professor of Industrial Technology
Purdue University

Abstract

This is the last of the four staff development workshops described in Division III, Overview. This workshop uses concept structures to identify strategies for evaluating performance and achievement. Primarily of interest to those responsible for staff development.

Indiana Tech Prep Training Manual: Division III
Sponsored by:
The Indiana Department of Education
Project # 92S-4762(TR)

This manual was developed at Purdue University
as part of the Tech Prep Staff Training Project (Project # 92S-4762(TR))
directed by
Dennis Depew, Department of Industrial Technology
and
J. Dudley Herron, Department of Curriculum and Instruction.

The training project and this manual were supported by funds from the Indiana Department of Education (IDOE). However, opinions expressed in this manual do not necessarily reflect the position or policies of the IDOE or the Indiana Department of Workforce Development. Rather, they represent the collective judgment of the high school teachers, university faculty, and project staff who so generously contributed to the manual. Names of contributors to each section of the manual are given on the title pages. A complete list of contributors can be found in Appendix A.

WORKSHOP 4: OVERVIEW
EVALUATING TECH PREP STUDENT PERFORMANCE

Yogi Berra, the oft quoted former manager of the New York Yankees, once commented to a reporter that the game "ain't over 'til its over!" The teaching-learning processes is much the same. There are several reasons for evaluating student performance. Most of these are readily apparent to educational professionals. The issue in this workshop is how to use the concept structures created to evaluate both learning *and* teaching.

Tech Prep represents a new approach to the education of the middle level students in our schools. Just as other workshops have shown how concept structures can guide the development of other elements of the teaching-learning continuum, the structure also provides a valuable guide to student and program evaluation.

A well developed concept structure is a road map to making test item budget decisions. The mutual independence of categories and the total inclusivity, and logical ordering, of each category provide an automatic test item hierarchy.

Paper and pencil evaluation of individual students based on an analysis of the concept structure is a relatively straightforward procedure. Test item development is a universal skill. What is not a universal skill is the development of performance tests. Since Tech Prep is a performance based approach, it is imperative that a substantial part of the evaluation also be performance based. Because the concept structures used to develop and present the course materials were derived from the action verbs (behaviors), and the actions are logically ordered, performance evaluation preparation guidelines are governed by how the concepts were originally structured.

Just as individual performance evaluation is guided by the content of the concept structure, so can group performance. If differential assignments have been made from the concept structure to accommodate individual talents and interest, so the concept structure serves as an evaluation standard to measure individual participant performance. Overall group performance is evaluated in much the same way, assuming the group assignment was initially based on a portion of the concept structure.

A final reason to use evaluation techniques is to determine from student performance the strengths and weaknesses of the Tech Prep offerings as they relate to intended outcomes defined in the concept structure.

WORKSHOP 4: TRAINER MATERIAL
EVALUATING TECH PREP STUDENT PERFORMANCE

*** WORKSHOP OBJECTIVES AND PRODUCT

** Workshop Objectives

As a result of participation in this workshop, Tech Prep professionals will be able to:

- Develop recommendations for the evaluation of group projects based on an analysis of Concept Structures and course materials
- Develop evaluation strategies for individual performance on group projects
- Use Concept Structures to prepare item budgets for evaluating teacher-centered instruction

** Materials Needed for Workshop

- Previously developed curriculum materials
- Previously developed course materials

** Workshop Product

- Group project evaluation recommendations
- Teacher-centered instruction evaluation recommendations

*** WORKSHOP INTRODUCTION

** Ask the participants to read the Evaluating Tech Prep Student Performance Overview prior to your presentation of this workshop

*** ISSUES IN EVALUATING TECH PREP STUDENT PERFORMANCE

Evaluation Strategies Must:

** Focus on the fact that Tech Prep instruction is a performance-based program

** Be designed to determine subject matter integration

** Measure the extent to which students can apply academic content to practical problems

*** USING CONCEPT STRUCTURES TO GUIDE EVALUATION STRATEGIES

** Concept structures provide the same guidance for measurement and evaluation procedures as they did for course development

** Concept structures establish levels of testing sophistication

- Higher order concepts permit evaluation of:
  - Academic content acquisition
  - Subject matter integration
- Lower order concepts permit evaluation of workplace performance capabilities

- ** Concept structure subconcepts use action verbs which define instructional activities:
  - * Find the Chemical Instrumentation Unit Assignment Sheet in Division II, Science Module 3, page 27-28.
  - * Your manual reproduces the Chemical Instrumentation Unit Assignment Sheet from the INDIANA TECH PREP TRAINING MANUAL. Note that:
    - * All topics are stated as action verbs
    - * Daily lessons within the unit progress from simple, concrete activities to more sophisticated and abstract activities, while remaining performance based.
  - * Evaluation criteria are implied in each topic
    - * Performance based (using)
    - * Applications based (calibrating)
    - * Theory based (interfacing)

*** DETERMINING EVALUATION PRIORITIES

The hierarchical nature of concept structure subconcepts makes it possible to differentiate between student achievement while insuring that minimum competencies have been identified for all students

- ** Establishing Minimum Competencies
  - * Typically defined by fourth-order or lower subconcepts
  - * Lower-order subconcepts are typically more activity oriented
  - * Logical order across subconcepts insures balanced evaluation
- ** Determining Higher Levels of Achievement
  - * Higher-order subconcepts are typically more theoretical
  - * Logical order within subconcepts establishes level of achievement by subconcept
  - * Logical order across subconcepts insures balanced evaluation of level of achievement

*** EVALUATING GROUP PROJECT ACTIVITIES

- ** Issues in Evaluating Group Projects
  - * Evaluating group performance
  - * Evaluating individual performance
- ** Comparing Student Performance to Concept Structures
  - * Comparing group performance to concept structures
    - * Does the group product adequately address the original concept structure
    - * Does the group product omit original concepts
    - * Does the group product identify new concepts
      - * Are new concepts appropriate
      - * Are new concepts inappropriate

- Comparing individual performance to concept structures
- Does the individual product adequately address the original concept structure
- Does the individual product omit original concepts
- Does the individual product identify new concepts
    - Are new concepts appropriate
    - Are new concepts inappropriate
- Should the original concept structure be modified based on results of the student evaluation

*** EVALUATING TEACHER-CENTERED INSTRUCTION

** Using the concept structure to identify performance- based evaluation strategies

- Refer to the Chemical Instrumentation Unit, the expanded subconcept structure from which Day 3 topics may be identified could be:
    - 1.0 Using a Digital Multimeter
        - 1.1 Selecting function
        - 1.2 Selecting range
            - 1.21 Estimating range
            - 1.22 Selecting higher range
        - 1.3 Measuring voltage
            - 1.31 Measuring AC voltage
            - 1.32 Measuring DC voltage
        - 1.4 Measuring current
            - 1.41 Measuring AC current indirectly
            - 1.42 Measuring DC current
                - 1.421 Measuring DC current directly
                - 1.422 Measuring DC current indirectly
        - 1.5 Measuring resistance
- Each subconcept represents a performance
- Lower order concepts define more specific performances
- Concepts requiring indirect measurements require both knowledge of the procedure and application of theory

** Using the concept structure to identify theory-based evaluation strategies

- Refer to the Chemical Instrumentation Unit, the higher order concept structure would include action verbs such as:
    - Determining conductivity
    - Measuring temperature
    - Analyzing gas mixtures
    - Analyzing unknown solutions
- Each subconcept requires knowledge of both a chemical or physical characteristic and a procedure to measure the characteristic

*** EVALUATING INSTRUCTION IN TECH PREP PROGRAMS

- ** Evaluation performance patterns can reveal strengths and weaknesses in Tech Prep programs
  - * What were the success patterns in content evaluations
    - * High achieving students
    - * Middle achieving students
    - * Low achieving students
    - * Multiple levels of students
  - * What were the failure patterns
    - * High achieving students
    - * Middle achieving students
    - * Low achieving students
    - * Multiple levels of students
- ** Performance patterns can often identify problem areas
  - * Inadequate prerequisite skills and knowledge
  - * Inappropriate delivery methods
  - * Improper evaluation strategies
- ** Performance patterns establish the data base for program modification and adaptation

*** EVALUATING STUDENT PERFORMANCE WORKSHOP ACTIVITIES

** Because most teachers are more familiar with evaluating teacher-centered content, begin the workshop activities with the development of group project evaluation strategies. Whenever possible, have the groups relate their efforts at the group projects prepared in the Instructional Materials Development Workshop.

** Closely monitor the time spent developing the group project evaluation strategies. At an appropriate time halt the development and conduct a discussion of the strategies developed by the individual workgroups.

** In the time remaining, charge the group with the task of using concept structures to evaluate teacher-centered instruction. Again, monitor progress and reserve time for whole group discussions.

WORKSHOP 4: TRAINEE MATERIAL
EVALUATING TECH PREP STUDENT PERFORMANCE

*** ISSUES IN EVALUATING TECH PREP STUDENT PERFORMANCE

Evaluation Strategies Must:

- ** Focus on the performance-based of Tech Prep
- ** Foster subject matter integration
- ** Measure the ability to apply theory to practical problems

*** USING CONCEPT STRUCTURES TO GUIDE EVALUATION STRATEGIES

- ** Concept structures can identify evaluation strategies
- ** Concept structures establish levels of testing
    - * Higher order concepts evaluate:
        - * Academic content acquisition
        - * Subject matter integration
    - * Lower order concepts evaluate performance capabilities
- ** Concept structure action verbs define instructional activities:
    - * Find the Chemical Instrumentation Unit Assignment Sheet in Division II, Science Module 3, page 27-28. Note that:
        - * All topics are stated as action verbs
        - * Daily lessons progress from simple to abstract activities, but remain performance based.
    - * Evaluation criteria are implied in each topic
        - * Performance based (using)
        - * Applications based (calibrating)
        - * Theory based (interfacing)

*** DETERMINING EVALUATION PRIORITIES

The hierarchy of a concept structure permits the testing of achievement differences while insuring that all have minimum competency

- ** Establishing Minimum Competencies
    - * Typically fourth-order or lower subconcepts
    - * Lower-order concepts are more activity oriented
    - * Logical order across concepts insures balanced evaluation
- ** Determining Higher Levels of Achievement
    - * Higher-order concepts are more theoretical
    - * Logical order within concepts establishes level of achievement by concept
    - * Logical order across concepts insures balanced evaluation

*** EVALUATING GROUP PROJECT ACTIVITIES

** Issues in Evaluating Group Projects

- Evaluating group performance
- Evaluating individual performance

** Comparing Student Performance to Concept Structures

- Comparing group performance to concept structures
  - Does the group product address the concept structure
  - Does the group product omit original concepts
  - Does the group product identify new concepts
    - Are new concepts appropriate
    - Are new concepts inappropriate
- Comparing individual performance to concept structures
  - Does the individual product address the concept structure
  - Does the individual product omit original concepts
  - Does the individual product identify new concepts
    - Are new concepts appropriate
    - Are new concepts inappropriate
- Should the original concept structure be modified based on results of the student evaluation

*** EVALUATING TEACHER-CENTERED INSTRUCTION

** Using the concept structure to identify performance- based evaluation strategies

- Refer to the Chemical Instrumentation Unit, the expanded subconcept structure from which Day 3 topics may be identified could be:

  1.0 Using a Digital Multimeter
  1.1 Selecting function
  1.2 Selecting range
  1.21 Estimating range
  1.22 Selecting higher range
  1.3 Measuring voltage
  1.31 Measuring AC voltage
  1.32 Measuring DC voltage
  1.4 Measuring current
  1.41 Measuring AC current indirectly
  1.42 Measuring DC current
  1.421 Measuring DC current directly
  1.422 Measuring DC current indirectly
  1.5 Measuring resistance
- Each subconcept represents a performance
  - Lower order concepts define more specific performances
  - Concepts requiring indirect measurements require both knowledge of the procedure and application of theory

- Using the concept structure to identify theory-based evaluation strategies
    - Refer to the Chemical Instrumentation Unit, the higher order concept structure would include action verbs such as:
        - Determining conductivity
        - Measuring temperature
        - Analyzing gas mixtures
        - Analyzing unknown solutions
    - Each subconcept requires knowledge of a characteristic and a procedure to measure the characteristic

EVALUATING INSTRUCTION IN TECH PREP PROGRAMS

- Evaluation performance patterns reveal strengths and weaknesses
    - What were the success patterns in content evaluations
        - High achieving students
        - Middle achieving students
        - Low achieving students
        - Multiple levels of students
    - What were the failure patterns
        - High achieving students
        - Middle achieving students
        - Low achieving students
        - Multiple levels of students
- Performance patterns can often identify problem areas
    - Inadequate prerequisite skills and knowledge
    - Inappropriate delivery methods
    - Improper evaluation strategies
- Performance patterns establish a data base for program modification

APPENDICES

Appendix A:	Contributors to the Indiana Tech Prep Training Manual
Appendix B:	Curriculum Materials for Applied Academics
Appendix C:	Catalog of Materials Available from the National Tech Prep Clearinghouse of Resources
Appendix D:	Indiana Schools Using Applied Courses
Appendix E:	Regional and National Reports Containing Lists of Competencies Important for Tech Prep
Appendix F:	Articulation Agreement: IVTC-Northcentral and Mishawaka
Appendix G:	Complete References

Appendix A

Contributors to the Indiana Tech Prep Training Manual

Tom Benjey, Math Writing Team Member, Indiana University.

Denise Briner, Science Writing Team Member, Columbus North High School.

Sarah Cassell, Associate Director, Indiana Tech Prep Teacher Training Program, Indiana University.

Jody Duncan, Science Writing Team Member, Bloomington High School South.

Dennis Depew, Project Co-Director, Purdue University.

Duane Dunlap, Technology Writing Team Head, Purdue University.

Sandy Ewing, Project Secretary, Purdue University.

James Green, English/Language Arts Writing Team Head, Ball State University.

Carolyn Hardy, English/Language Arts Writing Team Member, North Montgomery High School.

Larry Helphinstine, Technology Writing Team Member, Indiana State University.

Jeff Henderson, Technology Writing Team Member, Columbus East High School.

J. Dudley Herron, Project Co-Director, Purdue University.

Lori Hoevenor, English/Language Arts Writing Team Member, Bloomington North High School.

Stephen Houser, Assistant to Project Co-Directors, Purdue University.

Joan Houston, Math Writing Team Member, Columbus East High School.

Richard Hurt, Math Writing Team Member, Bloomington High School North.

Peter Kloosterman, Math Writing Team Head, Indiana University.

Kathryn Little, English/Language Arts Writing Team Member, Columbus East High School.

William Lumbley, Science Writing Team Member, Bloomington High School South.

Ross McKenna, Math Writing Team Member, Ben Davis High School.

Amy Mendenhall, English/Language Arts Writing Team Member, Ball State University.

Richard Mitchell, Science Writing Team Member, Purdue University.

Paul Modlin, Technology Writing Team Member, Mishawaka High School.

Mary Nakhleh, Science Writing Team Head, Purdue University.

Neil Owen, Technology Writing Team Member, Purdue University.

Tony Suba, Technology Writing Team Member, Ben Davis High School.

Alan Suess, Department of Industrial Technology, Purdue University.

Amy Sutley, Associate Director, Indiana Tech Prep Teacher Training Program, Indiana University

Paola Sztajn, Math Writing Team Member, Indiana University.

Appendix B

Curriculum Materials Related to the Integration of Vocational and Academic Education*

Applied Academics Courses

Principles of Technology, developed by the Center for Occupational Research and Development (CORD), Waco, Texas, in cooperation with the Agency for Instructional Technology (AIT), Bloomington, Indiana, and a consortium of state education agencies.

Applied Communication (AIT).

Applied Mathematics (CORD).

Basic and Academic Skills

ACTIVE: Academic Competency Taught in Vocational Education, State Department of Vocational Education, Lansing, Michigan (undated).

Applied Basic Skills Series, University of Texas at Austin, Division of Continuing Education, Extension Instruction and Materials Center.
    Vivian Caldwell et al., *Language Arts* (1988).
    Cam O'Keefe and Alan Towler, *Mathematics* (1988).
    Steve Fuller and Alan Towler, *Science* (1988).

Alan Towler, *Interfacing Math, Science, and Technology*, University of Texas at Austin, Division of Continuing Education, Extension Instruction and Materials Center (1987).

L.A. Grimes, Jr., *Integrating the Basic Skills into the ICC (Industrial Core Curriculum)*, University of Texas at Austin, Division of Continuing Education, Extension Instruction and Materials Center (1987).

---

*This list of curriculum materials is not a recommendation or endorsement of any of them, but is simply a listing of those we have examined. We have made no attempt to make this list comprehensive.

Donald Maley, *The Integration of Mathematics and Science into Technology Education: A Holistic Approach to Education*, University of Texas at Austin, Division of Continuing Education, Extension Instruction and Materials Center (undated).

Basic Skills in Consumer and Homemaking Education, State of New Jersey, Department of Education, Division of Vocational Education and Department of Home Economics, Glassboro State College, Glassboro, N.J. Lois Winand, project director; Vivian Gunn Morris, project coordinator; Jocelyn Walton, mathematics specialist; Kathleen Conroy, writing specialist; Nicholas Diobilda, reading specialist.

Mathematics in Consumer and Homemaking Education Programs: A Guide for Reinforcing Basic Skills (1987).
Reading in Consumer and Homemaking Education Programs: A Guide for Reinforcing Basic Skills (1987).
Writing in Consumer and Homemaking Education Programs: A Guide for Reinforcing Basic Skills (1987).

Basic Skills Improvement: A Handbook for Reading, Math, Writing, and Oral Communication, Barbara Dougherty and Jan Novak, project directors, and Judy Rodenstein and Keith Ruzicka, contributors, University of Wisconsin at Madison, School of Education, Vocational Studies Center (1986).

Barbara Nemko, *Model General Occupational/Employability Skills*, University of California at Davis, Department of Applied Behavioral Sciences (March 1986).

Building Basic Skills, available from the Center on Education and Training for Employment, Columbus, Ohio:

Thomas Long, *Basic Mathematics Skills and Vocational Education* (1980).
L. Jay Thornton, *Basic Reading Skills and Vocational Education* (1980).
Thomas Sticht and Larry Mikulecky, *Job-Related Basic Skills: Cases and Conclusions* (1984).
Lucille Campbell-Thrane et al., *Building Basic Skills: Models for Implementation* (1983).
James Weber and Cindy Silvani-Lacey, *Building Basic Skills: The Dropout* (1983).
Linda Lotto, *Building Basic Skills: Results from Vocational Education* (1983).

BASICS: Bridging Vocational and Academic Skills, available from the Center on Education and Training for Employment, Columbus, Ohio:
The Bridger's Guide (1987).
Instructional Program Development (1987).
Targeted Teaching Techniques (1987).

OTHER CURRICULA

Diversified Technology: A Technical Literacy Course for Students Pursuing "High Tech" Careers, Bureau of Vocational-Technical Education, Mississippi State Department of Education and Research and Curriculum, Unit for Vocational-Technical Education, Mississippi State University.

California State Department of Education, Division of Career-Vocational Education. *Model Curriculum Standards, Program Frameworks, and Process Guide* (1990). Available for each California career-vocational program area: agriculture, industry and technology, business, health careers, home economics, and marketing.

Texas Education Agency. *State Board of Education Rules for Curriculum*. Austin, 1990.

APPENDIX C

TECH PREP

National Tech Prep Clearinghouse of Resources

East Central Curriculum Coordination Center/Illinois State Curriculum Center
Sangamon State University, F-2
Springfield, IL 62794-9243

217/786-6375 • 800/252-4822 (In Illinois) • FAX: 217/786-6036

This special bibliography has been generated to meet your specific needs in the area of Tech Prep. To check out up to six items on a 30-day loan, write, call or visit the Curriculum Center. Please request items using the call number and title. Sample entry:

*I22TPPR980

Call Number → 375.24 OREG 1990-1

Title → 2 + 2 Tech Prep Program: Student Guide

Format → Report

Abstract → Describes the 2 + 2 Tech Prep program between Hillsboro Union High School (Hillsboro, Oregon) and Portland Community College. Students in their junior or senior year are able to earn advanced credit from the Community College. This student guide lists course requirements for a number of occupations.

And There's More . . .

. . . *Our Vertical Files Contain:*

- Legislative Information
- Promotional Brochures
- Articulation Agreements/Programs
- Proposals/RFPs
- Newsletters
- Contacts
- DACUM Charts
- Exemplary Programs

March, 1992

375.24 BARS 1991-1
1991 Spring Articulation Action Plan: 2 + 2
Report
Consists of the components of the articulation action plan for Barstow Community College District, Barstow, California, to provide a means to enable students from a secondary school to receive college credit for equivalent classes in the field of typing and drafting (2 + 2 Tech Prep). Includes copies of the resolution, agreements, certificate and sample transcript.

375.24 PERF 1989-2
2 + 2 + 2 Articulation Manual: A Joint Career/Vocational Education Partnership
Report
Consists of a compilation of agreements, instructions, forms, and details about 2 + 2 + 2 articulation and how it works between participating institutions. Designed to help administrators, counselors, and instructors understand the articulation process.

VT 375.24 MORE 1989-1
2 + 2 + 2 Fast Tracks II (Videotape)
Serves as a promotional tape for the 2 + 2 + 2 articulated program involving the State Center Community College District of Fresno, California. The intent of the program is to encourage students to define their career goals early in high school by trying one of these programs. Its purpose is to eliminate unnecessary redundancy by granting some type of advanced placement to high school students entering community college and to community college students entering four-year institutions.

649 LARS 1990-1
2 + 2 Articulation Instructional Program and Support Services: Early Childhood Development
Report
Presents the articulated instuctional program developed by Chabot College and the Hayward-New Haven Regional Occupation Center in the field of early childhood development. Includes three articulated plans within the program: 2+2 (2 years of high school and 2 years of junior college), 2+1 (2 years of high school and 1 year certificate program at the junior college), and 2+1+1 (2 years of high school, 1 year of general education and 1 year to meet AA degree requirements).

375.24 CENT 1989-1
2 + 2 Articulation: A "Win-Win" Experience: A Workshop on Tech Prep
Report
In workshop format this handbook includes materials for providing sessions on how to develop customized Tech Prep curricula and partnerships, types and examples of successful programs, how to involve key players and deal with critical issues, enhancements such as mentoring and employer incentives, and how to get support from federal and local sources.

BEST COPY AVAILABLE

375.24 KANS 1991-1
2 + 2 Connection
Report
Contains information on different 2+2 Associate, Certificate, or Transfer Programs available at Garden City Community College that have a direct connection to existing programs at Garden City High School. Packet consists of student handbook, brochures, participation statement, sample articulation agreement, final performance report and evaluation of program effectiveness.

621.38 SMIT 1989-1
2 + 2 Electronics: A Model Program Development Project
Report
Report of a project which developed a model 2 + 2 electronics program.

VT 651.8 VANA 1987-1
2 + 2 Information Processing Specialist Program (Videotape)
Designed to acquaint high school students with a 2+2 program which combines their 11th and 12th grade business education courses with a 2-year associate degree program in computer information systems at Lord Fairfax Community College, Middletown, Virginia. The video stresses the importance of planning goals for the future while still in high school. It lists courses and states the advantages of being prepared for current and new technology occupations.

375.24 MARM 1990-1
2 + 2 Program Guide: Tech-Prep Associate Degree Program, Business Administration Associate Degree Program, Office Administration Associate Degree Program, Allied Health Associate Degree Program
Curriculum Guide
Serves as a program guide to the Tech-Prep Associate Degree Program. This program begins in grade 11 at the secondary level. The student enrolls in a focused curriculum in science (Principles of Technology) math, and English - all taught in an applied setting. This enables the student to follow a postsecondary training program toward a career in the technical field.

375.24 MARM 1991-1
2 + 2 Tech-Prep Associate Degree Program: Annual Report 1989-1990, Program Summary 1987-1990
Report
Reports on the 2 + 2 Tech Prep Associate Degree Program between the Community College of Rhode Island and several secondary schools within the state. Includes general program information, a statistical report of program activities for the academic year 1989-1990, and a cumulative review of 2 + 2 since its beginning in 1987.

375.24 CENT 1991-1
2 + 2 Tech Prep Articulation: A "Win-Win" Experience
Report
In workshop format this handbook includes materials for providing sessions on how to develop customized Tech Prep curricula and partnerships, types and examples of successful programs, how to involve key players and deal with critical issues, enhancements such as mentoring and employer incentives, and how to get support from federal and local sources.

BEST COPY AVAILABLE

375.24 CENT 1990-1
2 + 2 Tech Prep Articulation: A "Win-Win" Experience: A Workshop on Tech Prep
Report
In workshop format this handbook includes materials for providing sessions on how to develop customized Tech Prep curricula and partnerships, types and examples of successful programs, how to involve key players and deal with critical issues, enhancements such as mentoring and employer incentives, and how to get support from federal and local sources.

649 PATT 1991-2
2 + 2 Tech Prep Early Childhood Professions II Curriculum Guide
Curriculum Guide
Designed for second year students of the 2+2 articulated Early Childhood Professions Program. Provides an introduction to the theories and practices in early childhood care and education, and opportunities to observe children in a variety of settings. Includes: professionalism; child growth, development, and learning; guidance and group management; curriculum development, content and implementation; family and community relations; safety, health, and nutrition; and program management.

649 PATT 1991-1
2 + 2 Tech Prep Early Childhood Professions I Curriculum Guide
Curriculum Guide
Designed for first year students of the 2+2 articulated Early Childhood Professions Program. Provides an introduction to the theories and practices in early childhood care and education, and opportunities to observe children in a variety of settings. Includes. professionalism; child growth, development, and learning; guidance and group management; curriculum development, content and implementation; family and community relations; safety, health, and nutrition; and program management.

375.24 OREG 1990-1
2 + 2 Tech Prep Program: Student Guide
Report
Describes the 2 + 2 Tech Prep program between Hillsboro Union High School (Hillsboro, Oregon) and Portland Community College (Portland, Oregon). Students enroll in their junior or senior year and are able to earn "advanced credit" from Portland Community College. This student guide lists course requirements for a number of occupations.

610.73069 TEXA 1990-1
2+2 Articulated Curriculum for Health Occupations: A How-to Manual
Curriculum Guide
Serves as a how-to manual for secondary and postsecondary administrtors interested in developing and implementing 2 + 2 articulation programs. Uses the 2 + 2 articulated career ladder curriculum for the registered nurse. Includes definitions of articulation, advanced placement, tech prep, technical education, 2 + 2, and 2 + 2 + 2 articulation. Includes facilities, tools and equipment for curriculum.

610.73069 TEXA 1990-2
2+2 Articulated Curriculum for Health Occupations: A Basic Course Outline Grade 11 Nursing
Curriculum Guide
Serves as a basic course outline for Grade 11 in the field of nursing. Combines academic and clinical experience to develop and demonstrate the beginning level knowledge and skills for the occupation of a registered nurse in the 2 + 2 Articulated Health Occupation Program Includes facility drawing, supplies and equipment list, student competency profile, and matrix of essential elements of competencies Guides are available for each year of the program.

610.73069 TEXA 1990-3
2+2 Articulated Curriculum for Health Occupations: A Basic Course Outline: Grade 12 Nursing
Curriculum Guide
Serves as the basic course outline for Health Careers II, (Grade 12). Helps students develop and demonstrate mastery of the knowledge and skills necessary to articulate to the postsecondary level of continued training as a registerd nurse. This is the second course of 2+2 Articulated Health Occupations program for registered nurses. Includes facility drawing, tool and equipment list, competency profile, and matrix of essential elements to competencies. Guices are available for each year of the program.

375.24 PERI 1990-1
2+2+2 Articulation: A Partnership for Excellence
Curriculum Guide
Serves as a training resource for teachers, counselors, and students as well as a basic articulation reference. Provides a complete set of working papers and forms for each articulated program. Articuated programs include such areas as mathematics, communications, automotive, business, electronics, fire technology, horticulture, and welding.

363.2 CRUI 1988-2
2+2+2 Law Enforcement Program
Curriculum Guide
Serves as an articulation program for law enforcement in Virginia. Competencies pertain to duties in the areas of criminal justice, traffic control, arrest, and more. Includes: Law Enforcement Task Analyses, New Horizons Technical Center 2+2+2 Program, Thomas Nelson Community College 2+2+2 Program, and Christopher Newport College 2+2+2 Program.

375.24 TRIC 1990-2
Articulation Agreement Booklet Between McDuffie High School and Tri-County Technical College
Report
Serves as a student handbook to explain how to plan a course of study to take advantage of the Tech Prep program at the high school level and of articulation between McDuffie High School and Tri-County Technical College which allows the earning of technical advanced placement through exemption credit.

629.23 CENT 1989-1
Articulation Agreement for Automotive Technology
Report
Consists of the articulation agreement between Central Virginia Community College and Lynchburg City Schools, Appomattox County Public Schools, and Amherst County Schools for automotive technology.

371.4 LARS 1990-1
Articulated Counseling, Guidance, Advising Model: To Accompany Articulated Instructional Programs
Report
Serves as a model 2 + 2 articulation project for counseling, guidance and advising services that was an objective of the second year grant awarded to Chabot College, Hayward, California. Includes the objectives of the planned workshops, the organization, response to the five tasks to perform, and the model for use in articulation.

375.24 TEXA 1989-1
Articulation: Establishing a Definition
Report
Compilation of articulation definitions, includes a section showing articulation activities in the categories of curriculum and instruction, program management, student services and community resources.

375.24 PHEL 1988-1
Articulation in Virginia: Coordination of Secondary/Postsecondary Education
Curriculum Guide
Reviews cooperative efforts between community colleges and secondary school divisions in Virginia. Special attention is given to model 2 + 2 programs. Includes current plans and initiatives and a directory of contact persons.

375.24 SCHM 1984-1
Articulation of Vocational Education Programs in Arizona
Report
Describes a study of articulation of vocational education programs in Arizona which was intended to provide a framework by which a more effective system of vocational training can be established in Arizona.

375.24 MEYE 1990-1
Advanced Placement and Articulation Agreement between Four County Joint Vocational School and Northwest Technical College
Report
Includes an articulation agreement describing the guidelines by which a secondary student may earn advanced credits in the college setting. Explains the procedures a student follows to apply for advanced credits and the role each institution carries out in this context. Also includes course listings and descriptions for the business, engineering and early childhood education programs.

623

375.24 MARY 1984-1
Articulated Programs Between High Schools and Community Colleges in Maryland
Report
Discusses high school-community college articulation efforts in Maryland. One approach is based on a college granting advanced placement or credit to high school students to save time and money toward a college degree. The second approach emphasizes an integrated two-plus-two (2 + 2) curriculum between high schools and community colleges. Includes sample articulation agreements.

697 MILW 1986-1
Articulation Plan for Custer High School Milwaukee Public Schools and Milwaukee Area Technical College: Program: Air Conditioning and Refrigeration
Report
Serves as the articulation guide for Milwaukee Area Technical College and Custer High School air conditioning and refrigeration programs. Charts a prescribed program for the student taking full advantage of the articulation agreement. The first chart lists the congruent courses which enable advanced standing. The second chart presents an advanced skill program of study, substituting electives for courses eliminated through articulation.

621.8 MILW 1989-1
Articulation Plan for Cudahy High School and Milwaukee Area Technical College: Program Area: Computerized Machining
Report
Serves as the articulation plan for Cuahy High School and Milwaukee Area Technical College in the industrial technology department. Charts a prescribed program for the student in the program area of computerized machining. The first chart lists the congruent courses which enable advanced standing. The second part presents an advanced skill program substituting electives for courses eliminated through articulation.

650.1 MILW 1987-1
Articulation Plan for Greenfield High School and Milwaukee Area Technical College: Progrm Area: Business Courses
Report
Contains the articulation agreement between Milwaukee Area Technical College and Greenfield High School. Charts a prescribed program for the student taking full advantage of the articulation agreement. The first chart lists the congruent courses which enable advanced standing. The remaining charts contain examples of the business programs of study that utilize the articulation agreement.

649 MILW 1988-1
Articulation Plan for West Allis/West Milwaukee Public School System and Milwaukee Area Technical College: Program Area: Home Economics--Child Care
Report
Serves as an articulation plan for West Allis/West Milwaukee Public School System and Milwaukee Area Technical College in the home economics child care program. Illustrates a 2+2 articulation agreement and also a 3+1+1 agreement.

BEST COPY AVAILAB

375.24 BROO 1989-1
Articulation: The Critical Link to Educational Opportunities
Report
Consists of a portfolio of materials to be used as a guide for implementing articulation. Includes: goals, guidelines, requirements, suggestions for meetings, procedures for updating signed articulation agreements, sample forms, newsletter, pamphlet, and transparencies.

375.24 BRAD 1986-1
Articulation: Guidelines for Development of a High School to College Agreement
Report
Consists the three chapters: an overview of articulation, fill-in the blanks form that can be used to guide negotiation of an articulation agreement, and examples of the documents needed to finalize an articulation agreement.

650 ANDE 1987-1
Advanced Standing Agreement: Waukesha County Technical Institute and New Berlin Schools, January 1987
Report
Contains the advanced standing agreement between Waukesha County Technical Institute (WCTI) and New Berlin School in Wisconin, which allows for the students graduating from New Berlin High School who have attained technical competencies required in the account clerk program, data processing machine operations program and the clerk typist program to receive automatic credit in specific courses at WCTI. AAS data processing courses are also subject to automatic credit.

373.246 CAMP 1990-1
Articulation Tech Prep Workbook for Cooperative Education
Report
Designed to assist those interested in developing and implementing articulation programs specifically related to cooperative vocational education. Appendices include: terminology, credit-granting considerations, sample agreements, guidelines, and external support information.

375.24 KEY 1991-1
Building a Transportable Model for Tech-Prep Systems Geared for the Twenty-First Century
Report
Provides models for planners of tech prep programs, a checklist of planning concerns, a public relations campaign strategy, tips for institutionalization, and an analysis of the Tech Prep section of the Perkins Law.

375.24 CALI 1987-1
Building the Bridge for Better Education
Report
Discusses the interaction and outreach activities taking place between community colleges and secondary schools in California. Explores the benefits and barriers of articulation, plus the criteria for a successful program. Emphasizes strong student services including counseling and academic advising in order to coordinate each student's educational experiences.

375.22 CENT 1986-1
Competency Based Education: A Practical Approach
Report
Discusses working definitions for competency based education and competency-based performance testing. Includes glossary of CBE terms.

375.24 SCUT 1989-2
Career Bound: Walhalla High School Plan Book: A Career Planning Guide. . . Success by Design
Report
Designed to help studentss in making choices in their career development and to evaluate their options at Walhalla High School. Encourages setting goals and obtaining the necessary training, education, and experience during their high school years. Includes tech prep program (4 + 2 plan). Gives high school courses of study and jobs one might enter when following a particular study program. Includes brochure.

378.1543 MARI 1990-1
The Community College Movement and Examples of Modern American Educational Alliances in the Maricopa Community College District
Report
Discusses the essential elements of a community college, the evolution of the community college system, the academic alliances, the employer-educator alliances, the inter-institutional educational alliances, and stresses the importance of these alliances. Discusses the Maricopa Community College District in particular.

VT 610.73069 GOLD 1989-1
Career Connection: Nursing 2+2+2 (Videotape)
Pictures the advantages of entering the nursing profession. Stresses choosing nursing while in high school and continuing the education into junior college and higher education through articulation procedures. The booklets serve as a model for articulation using five planning components: leadership, orientation and in-service, articulation, outreach and tracking.

375.24 RAME 1991-1
Community College/High School Articulation in California: 2 + 2 Program Definition and Barriers to Implementation
Report
Gives the results of a research study to determine the definition of 2+2 programs and their components and the barriers to the implementation of 2+2 programs in California. Includes recommendations.

375.24 AIKE 1988-1
Careers for the Future: A Counseling Handbook
Report
Includes a promotional brochure and counseling handbook designed to assist high school freshmen in planning their program of study. Describes associate degree occupational programs offered at Aiken Technical College and includes pertinent career and academic information.

363.2 WALL 1990-1
Communications for the Workplace: Applications from Criminal Justice Technology, A Teacher's Guide
Curriculum Guide
Emphasizes effective communication skills in the workforce. Presents a real-world context where written communication skills are used as part of the daily routine of a law enforcement officer. Helps students see the need to be as specific and concise as possible when completing documents as part of job requirements.

375.02 GRUB 1990-1
The Cunning Hand, the Cultured Mind: Models for Integrating Vocational and Academic Education
Report
Serves as a draft or preliminary report based on research in progress to integrate academic and vocational education. Identifies eight models of integrating academic and vocational education, each with several variations.

375.24 WERN 1989-1
Coordination of Occupational/Vocational Education
Report
Serves as the sixth update of the five year Maricopa County Plan that was adopted in 1985. The original goal of the plan was coordination of secondary, postsecondary, and university level vocational education so that students could progress without duplication of time, effort, or expense. Includes a progress report, FY1989-90 goals and objectives, and recommendations. Appendices include inventory of occupational programs and articulation procedures.

375.02 CENT 1987-1
Criterion-Referenced Measures
Report
Explains criterion-referenced measures, and how to develop and use them. Includes sample materials.

371.425 SUTH 1989-1
Career Tech Prep 4 + 2: A Collaborative Project
Final Report
Consists of information on the Vocational Education Collaborative Career Guidance and Job Placement Projects between Lewis Cass Intermediate School District and Southwestern Michigan College. The goal of this project was to provide job placement services in collaboration with schools, community agencies, and businesses to secondary and post-secondary students in Cass County. Includes final report. Lists course offerings for specific career clusters and includes classroom materials for employability skills.

375 EDUC 1989-1
Developing Articulation Agreements for Education for Employment Report
Provides information necessary for developing articulation agreements between Education for Employment systems and their respective community college districts in Illinois. Describes a rationale for articulation, provides an overview of the articulation process, and describes procedures for developing articulation agreements.

BEST COPY AVAILABLE

375.24 CAMP 1987-1
Delaware Consortium on Technical Preparation Programs: Report to the General Assembly
Report
Describes the Delaware Consortium on Technical Preparation Programs (Tech Prep) and discusses 5 specific articulation projects in Delaware. For each project, it describes the purpose, impact areas, and program status.

378.1543 ELLI 1988-1
Directions in Postsecondary Vocational Education
Report
Looks at what institutions are doing to meet the challenges put forth by the changing needs of America's businesses and industries. Presents arguments for stronger articulation and discusses narrowing the gap between classroom training and immediate skill requirements of employers.

604.24 LARS 1990-1
Drafting Technology: 2 + 1, 2 + 1 + 1, 2 + 2
Report
Presents the articulated instructional program developed by Chabot College and the Eden Regional Occupation Center, California, in the field of drafting technology. Includes three articulated plans within the program: 2+2 (2 years of high school and 2 years of junior college), 2+1 (2 years of high school and 1 year certificate program at junior college), and 2+1+1 (2 years of high school, 1 year general education and 1 year to meet AA degree requirements).

604.24 LARS 1990-2
Drafting Technology: 2+1, 2+1+1, 2+2
Report
Presents the articulated instructional program developed by Chabot College and the Tri-Valley Regional Occupation Program, California, in the field of drafting technology. Includes three articulated plans within the program: 2+2 (2 years of high school and 2 years of junior college), 2+1 (2 years of high schol and 1 year certificate program at junior college), and 2+1+1 (2 years of high school, 1 year of general education and 1 year to meet AA degree requirements).

370.1932 GRUB 1989-1
The Developing Vocational Education and Training "System": Partnerships and Customized Training
Report
This article reprinted from the "Proceedings of the Tenth Annual Rupert N. Evans Symposium" focuses on a particular kind of partnership--customized training. Customized training differs from conventional vocatonal education in that it prepares students for a specific employer rather than preparing them for the labor market in general.

628

VT 621.3 MACG 1991-1
Electricity, Electronics, Technology: 2+2 Circuits to Success (Videotape)
Serves as a promotion tape for the Electricity, Electronics, 2+2 Technology program between Central Virginia Community College and the school divisions in the Lynchburg Metropolitan Area. Focus is on preparation through a combination of secondary and postsecondary programs to prepare students for entry into a variety of occupations. The guide contains the task inventory, course descriptions, teaching sequences, and course outlines.

370.1931 PACE 1990-1
Guide to Area Business Speakers: A Resource for Teachers and Counselors
Report
Serves as a guide for teachers and counselors to area business speakers. These speakers emphasize to students the importance of staying in school, applying themselves, and preparing for a more technically-oriented workplace. Contains suggestions on how to set up programs, speaker data sheets, and evaluation forms. It is color-coded for easy identification of each business category.

375.24 MCCL 1988-1
Getting To Know You: The Secondary-Postsecondary Connection
Report
Reports on articulation programs in the state of Washington. Serves as a guidebook for high school, community college, and vocational-technical staff. Includes steps for successful articulation and answers frequently asked questions about the feasibility of articulation. Contains numerous forms, sample agreements, and program models.

371.218 FARL 1988-1
High School Articulation
Report
Provides an overview of articulation activities between the community colleges and secondary schools of California. Reviews the progress made in the implementation of articulated 2 + 2 vocational education projects.

375.24 FULL 1989-1
Inhibitors and Enhancers of Articulation Between Illinois Education for Employment Regional Systems and Community Colleges
Report
Purpose of the study was to identify the inhibitors and enhancers of articulation between Illinois education for employment regional systems and community colleges. Includes summary of results of survey to the regional systems and recommendations.

VT 375.24 INDI 1991-1
Indiana Department of Education Presents: Tech Prep Teleconference (Videotape)
Presents the Indiana's Tech Prep Teleconference held on May 9, 1991 demonstrating several prototypes of their program using competency based instruction, cooperative learning, problem solving, and teamwork training. Integrates math, science, and English language into all courses. Includes secondary and post secondary sequence models as well as dual credit, advanced study, and cooperative arrangements.

375.24 GRUB 1991-1

An Information Exchange on Tech-Prep Programs

Report

Describes a research project which will examine the variety of tech-prep programs, and provide the information both for technical assistance to other institutions wanting to set up such programs and to the Department of Labor as they implement the tech-prep provisions of the Perkins Amendments of 1990.

375.24 OHIO 1988-1

In the Articulation Spotlight

Report

Identifies major articulation activities between secondary and postsecondary schools that are working well in Ohio. Identifies the components of such activities and the benefits to be derived from them by both educational systems. Ohio currently uses two approaches to articulation: time-shortened programs and advanced-skills programs. Advanced skills programs consists of two types, core curriculum (pre-tech) and true 2 + 2 programs.

371.46 BOTT 1989-1

Improving the Communications, Mathematics, and Science Competencies of Students Enrolled in Vocational Courses: A Report on the Secondary Annual Staff Development Conference of the SREB-State Vocational Education Consortium

Report

Contains the summary of the Second Annual Staff Development Conference of the SREB-State Vocational Education Consortium. Suggests programs and ideas that are directed to helping schools provide students with basic competencies and technical knowledge necessary to succeed in today's and tomorrow's ever-changing society.

373.2365 AAGA 1990-1

Industrial Technology Course Modules for Explorations in Technology, Grades 7 & 8

Curriculum Guide

Consists of industrial technology course modules designed for students in grades 7 and 8. These modules allow students to work independently or cooperatively in pairs and encourages them to use acquired knowledge and creative thought. Topics include: applied physics, audio communications and radio, CAD, numerical control, desk top publishing, electricity, electronics, introduction to computers, robotics, visualization, and transportation.

373.2365 AAGA 1991-1

Industrial Technology Course Modules for Explorations in Technology, Sixth Grade

Curriculum Guide

Consists of industrial technology course modules designed for students in grade 6. These modules allow students to work independently or cooperatively in pairs and encourages them to use acquired knowledge and creative thought. Topics include: aerostats, computer drafting, communications, mass production, measurement, paper flight, robotics, tools, graphics, transportation.

600 AAGA 1991-1
Industrial Technology Course Modules for Investigations in Technology (Ninth and Tenth Grades)
Curriculum Guide
Consists of industrial technology course modules designed for 9th and 10th grade students. These modules allow students to work independently or cooperatively in pairs and encourages them to use acquired knowledge and creative thought. Topics include: inventions, flight, communication, holography, jobs, lunar design, problem solving, system dynamics, telecommunication, and computer programs Hypercard and Stella.

600 ROBE 1990-1
Imagine Tomorrow: The Technical Preparation Program
Report
Designed as a resource document that outlines the high school and community college programs which comprise the Technical Preparation Program. This program is a planned academic experience for the 11th and 12th grades, continuing through two years of college. This is a promotional packet of materials.

375.24 CALI 1991-1
Joint Santa Barbara High School District/Santa Barbara City College Articulation Program.
Report
Gives the five points around which the articulation cooperative programs are organized between Santa Barbara High School District and Santa Barbara City College. Provides the administrative regulations establishing the membership and functions of the Articulation Council Committees. Includes articulation agreements for the following program areas: automotive technology, drafting, electronics/computer technology, graphic communications, associate degree nursing, vocational nursing, and word processing.

375.24 ADAM 1990-1
Model Articulation Project (2+2+2): Vocational Education Articulation Project
Report
Serves as the counselor/teacher's manual for the Phase III Articulation Project which consists of Cerritos College, four California unified school districts, and California State University at Los Angeles. This 2 + 2 + 2 program includes two years of high school study, two years of community college study, and two years of study at the university level. The articulated programs include automotive technologies, drafting and design, electronics, manufacturing, and business education areas.

620 WALL 1990-1
Mathematics for the Workplace: Applications from Engineering Technology
Curriculum Guide
This module is designed to help students understand the significance of mathematic skills in the field of engineering technology. Provides occupational information for becoming an engineering technician. Includes one task based on testing Kevlar, which is a fiber, manufactured by Clark-Schwebel Industries. Includes problem questions and answers.

631

375.24 METR 1989-1
Metro-Milwaukee Employment Curriculum Articulation Project: A Manual of Models for Articulation
Report
Provides a detailed guide to the implementation of an articulation program between Milwaukee Area Technical College and participating high schools entitled M-MECAP. Provides students with a nonduplicative sequence of progressive achievement leading to competencies in a TECH PREP education program. This is a manual of models for articulation and includes sample forms, etc.

621.38 FOST 1990-1
2 + 2 Electronics Technology: Looking Forward to the Future
Report
Describes an electronics TECH PREP program between San Antonio College and several school districts. Gives information needed to implement the program at the high school level and includes an overview of the project design, recommended high school academic courses, course competencies for electronics technology, course outlines, facility drawing, tool and equipment list, articulation agreement, etc.

375.24 NORT 1991-1
The North Dakota Tech-Prep Initiative
Report
Reports on North Dakota's initiative to create a Tech-Prep program which meets the needs of a rural, sparsely populated state with limited resources and limited postsecondary offerings. Includes a Tech-Prep Draft Model to mid-level technology careers and lists program student outcomes and implementation issues.

VT 610.73069 FELD 1990-1
Nursing in Tidewater Virginia (Videotape)
Discusses the different types of nursing and nursing careers in the Tidewater area. Lists schools in Virginia that offer nursing courses. Points out what is required to be a practical nurse or a registered nurse. Focuses on The Tidewater Regional Articulation Project and their Associate Degree nursing program.

370.113 NEVA 1990-1
New Programs for a New Age
Report
This flyer describes Nevada's Occupational Education Program for grades 7 through 12 and lists the 5 courses involved. Briefly describes program which uses hands-on applied learning techniques and emphasizes academics--math, science, communication skills, technical skills, and work ethics.

375.24 NATI 1989-1
Occupational Program Articulation
Report
Summarizes the results of a survey of 675 two-year post-secondary institutions designed to define and identify articulation activities, evaluate articulation efforts, and identify model programs. Includes definitions of types of articulation programs: Advanced Placement, Tech Prep, 2 + 2 Articulation, and 2 + 2 + 2 Articulation.

651.3 OREG 1990-1
Office Systems: Competency Based Program Content Standards for Office Occupations
Curriculum Guide
Contains information for use by curriculum planners, teachers, etc. involved with new program development or revisions of existing programs. Includes the approval criteria for an office systems cluster program. Employment skills and attributes have been identified by representatives from business and industry. Content standards may be used as a basis for articulation. Essential skills are cross-referenced to the suggested course titles. Includes competency profile.

600 OREG 1989-1
Oregon Technology Systems Education Program Model
Curriculum Guide
Focuses on Oregon's Technology Systems Education model that will help students prepare for a future in the workplace by reinforcing science, math, communications, and humanities subjects/theories into an applied, hands-on setting as well as actual work experiences. Includes possible articulation agreements with community college programs and other post-secondary institutions.

VT 375.24 ILLI 1991-2
Partnerships: World Class Workforce (Videotape)
Promotes the idea of developing Tech Prep programs for the state of Illinois. Notes the need for forming partnerships, developing curriculum, and planning programs. Focuses on restructuring vocational education through an alliance between academic and vocational teachers, association between secondary and postsecondary schools, and cooperation between education and business. Sees Tech Prep as the opportunity for students to get jobs and employers to get skilled workers.

671 HUMA 1991-1
Proposed Duty Standards for General Production Technician Occupations in the Metalworking Industry in Illinois: Manufacturing Tech Prep Project
Report
Describes the proposed framework for industry skill standards for metalworking occupations and the draft set of duty performance standards for Production Technician I occupations.

371.218 WHIT 1989-1
Planning for Articulation: 2 + 2 Vocational Education Programs
Report
Provides an overview of 2 + 2 programs and differentiates between 2 + 2 and other articulation strategies. Addresses how to make it work and the barriers which hinder success. Includes a chart listing 2 + 2 programs identified through a literature search. This document is meant to promote and encourage articulation and the visioning of a broader and better vocational program in Hawaii.

375.24 OSWA 1991-1
Preparation for the Technologies: Program of Study Guide
Report
Serves as a resource guide in developing a Preparation for the Technologies Program of Study. Contains a suggested action plan and a list of course selections for specified occupational clusters. Focuses on tech prep articulation procedures, applied academics, identifying core competencies, and funding. Includes a suggested model for setting up a tech prep program and a promotional brochure.

375.24 SOUT 1990-1
Preparation for the Technologies: Program of Study Proposal
Report
Serves as a proposal for a South Carolina program of study to implement a core curriculum designed to prepare skilled workers to meet the needs of the technical workplace and to link the educational delivery systems at the secondary and postsecondary levels (4 + 2 Tech Prep). Program emphasizes problem solving skills, cooperative learning and peer counseling. Includes model.

375.24 CUNN 1990-1
Pendleton High School and TechPrep: Pursuing Higher Standards for You!: Student and Parent Guide 1990-91
Report
Serves as a student and parent guide for South Carolina's Pendleton High School's Tech Prep program. Includes the Tech Prep suggested course guides and the Technical Advanced Placement Program (TAP).

375.24 CUNN 1990-2
Pendleton High School Curriculum Guide 1990-91
Report
Serves as South Carolina's Pendleton High School registration information packet. Defines the school's three-track system and gives the curriculum requirements for each. Includes course descriptions.

375.24 MEAN 1991-1
Proposal of Partial Funding for HI/VO/CO/Project of Tech-Prep Education for Fiscal Years 1992-94
Report
Discusses the proposal for a planning and demonstration grant for a tech-prep program, identified as HI/VO/CO (High School/Vocational School/College) submitted by the Patriot Consortium of Oklahoma County. A 2 + 2 Tech Prep program will be developed during 1992 and a 2 + 2 + 2 Tech Prep program will be developed during 1993-94. Lists program competencies for all instructional areas.

375.24 MARY 1990-2
Proposed Tech Prep Clusters: Secondary Programs
Report
Consists of proposed Tech Prep Clusters for applied engineering and mechanical technologies; applied health and human services technologies: and applied business and management technologies. Gives the proposed four-year course sequence for programs within these clusters.

BEST COPY AVAILABLE

634

375.24 JOHN 1990-1
Preparing Workforce 2000 through Vocational Technical 2 + 2 Programs: Annual Report 1990
Report
Serves as the fourth annual report of the Portland Area Vocational Technical Education Consortium (PAVTEC) on their efforts in developing high quality articulated programs throughout the region in response to the demands of the Oregon Legislature's "Workforce 2000 Act of 1989". This is both a summary of past accomplishments and a forecast of those yet to be achieved.

658.3042 TURL 1990-1
Resource Handbook for Teachers and Counselors: A Collection of Ideas, Facts, Resources, and Project Summaries from the 1990 PACE Summer Institute
Report
Provides an overview of ideas, facts, and resources offered during the 1990 PACE Summer Institute. Informed participants about mid-level technology career and other non-traditional fields and recommended strategies to prepare students for these careers. Also focused on improving students motivation and self-esteem.

652.3042 TURL 1991-1
Resource Handbook for Teachers and Counselors: A Collection of Ideas, Facts, Resources, and Project Summaries from the 1991 PACE Summer Institute
Report
Provides an overview of ideas, facts, and resources offered during the 1991 PACE Summer Institute. Informed participants about mid-level technology careers1 and other non-traditional fields and recommended strategies to prepare students for these careers.

375.24 NATI 1991-1
Resources on Tech Prep Programs
Report
Includes brief descriptions of sample exemplary programs, lists of national curriculum centers and state contacts for tech prep programs, a tech prep bibliography and a list of available state reports and ERIC documents.

375.24 PERF 1990-1
Statewide Articulation Conferences Project (Final Report)
Final Report
Final report for a project designed to plan and conduct two statewide conferences on 2 + 2 Career-Vocational Education Articulation, to share information, dissemination materials, discuss issues, and showcase model projects.

375.24 CAMP 1990-1
Secretary's Award Program Tech Prep
Report
Describes the 2 + 2 Tech Prep articulation between Delaware Technical and Community College, Wilmington College and the Delaware state-wide vocational schools which produces two years of technical education at the high school level and two more years at the post-secondary level resulting in an Associate degree.

607 IDAH 1990-1
Scope and Sequence for Industrial Technology Education and Trade, Industrial and Technical Education
Report
Describes the courses in industrial technology education, industrial arts, and trade industrial and technical education for grades 7-12. Categorizes them as to exploration, foundation, and occupational concentration courses.

373.23619 DAVI 1989-1
Strengthening Basic Skills through an Integrated Middle School Curriculum
Curriculum Guide
Contains the project of the New Bern-Craven County Schools in North Carolina to bridge the gap between vocational and academic educationby correlating the competencies and strategies which are shared by the academic and career exploration teachers. Includes competencies, career exploration strategies and activities for math, science, social studies, communication, physical education, art, music and guidance.

VT 375.24 TAPL 1990-1
Sierra College 2 + 2 Video (Videotape)
Serves as a promotional tape for Sierra College's 2 + 2 program. Points out the importance of staying in school and getting into the program in order to be skilled for the future. Video does not explain how the program works, but rather demonstrates why to become involved in the program.

375.24 PERF 1988-1
Sierra Community College Joint Career, Vocational/Occupational Education Articulation Project Final Report: Phase II (Implementation)
Final Report
Final report for phase II of Sierra articulation project. During this phase, the project was expanded to include adult education and middle school representation. Appendices include comparison chart for academic standards, model for early childhood development agreement, and generic model with automotive technology.

375.24 PERF 1989-1
Sierra College Joint Career/Vocational Education "2+2" Articulation Project Final Report, Phase III (Institutionalization)
Final Report
Serves as the final report of Phase III of the articulation project at Sierra College. The focus of this phase was on the institutionalization of the articulation process. Program was expanded to include additional schools and subject areas, including early childhood development and agriculture. Includes review of project activities, anticipated outcomes versus actual outcomes, project dissemination, follow-up activities and internal evaluations.

375.24 SOUT 1988-1
Student Career Planning Guide
Report
Discusses the two major curriculum options at Liberty High School in Liberty, South Carolina: the Four-Year College Prep option and the Tech-Prep/Preparation for Technologies option.

636

375.24 MARY 1991-1
St. Mary's County Public Schools High School Program of Studies 1991 - 1992
Report
Describes Maryland's St. Mary's County Public Schools high school program of studies for 1991-1992. Includes diplomas and certificates, graduation requirements, competency based testing, alternatives to the four-year enrollment, grade level designations and grading scales and averages, student placement, advanced placement, tech prep clusters, and course descriptions. Appendices include articulation agreements, Tech Prep four-year course sequence, and Maryland University admission requirements.

375.24 BLAN 1990-1
Secondary Postsecondary Articulation Handbook: Guide to Articulation Programs
Report
Discusses articulation, 2 + 2 articulation programs and 2 + 2 tech prep/associate degree program. Provides definitions, program considerations, procedures, and sample agreements, forms, and student articulation credit plan. Includes a listing of community college articulation agreements with secondary schools actual and anticipated for 1990 for Massachusetts.

600 VIRG 1986-1
A Secondary/Postsecondary Program to Prepare Master Technicians
Report
Report of a project to develop a program to train master technicians that involved collecting input from local industry and trade. This pilot project was tasked to develop a 2 + 2 model in the technical field of electronics/electromechanical technology.

375.24 TRIC 1990-1
Technical Advanced Placement Handbook for Faculty and Staff
Report
Assists faculty, department heads, counselors, and staff in managing the procedures associated with the Technical Advanced Placement (TAP) program--advanced credit for high school students from Tri-County Technical College in South Carolina. Procedures are associated with Tech Prep because they eliminate gaps and overlaps between secondary and postsecondary levels of education. Appendices include sample forms.

375.24 TRIC 1990-3
Tri-County Technical College Technical Advanced Placement (TAP) -1990: Materials Packet
Report
Serves as a general articulation information packet for Tri-County Technical College Advanced Placement programs (TAP). Contains procedures for advanced placement in computer technology, fashion merchandising, and office systems technology. Also includes competency checklists for each area including microcomputer applications competencies.

375.24 EAST 1991-1
Technology Education Preparation
Report
Contains the Technology Education Program between East Central College in Union, Missouri and surrounding schools. Developed as a technologies preparation associate degree program for high school students and to raise community awareness about the connection between technical job opportunities and the educational curriculum.

375.24 HULL 1991-1
Tech Prep Associate Degree: A Win/Win Experience
Textbook
Contains rationale, methodology, structure, process, and advice for forming and operating a Tech Prep Associate Degree (TPAD) Consortium. Gives examples of programs developed across the country by different types of people, in different environments, and for different purposes. Addresses the issue of recruiting and retaining TPAD students. Deals with the feelings and appraisals of people who have experienced a TPAD consortium. Discusses the role of applied academics in the TPAD curricula.

375.24 NORT 1991-2
The Tech Prep Connection: Building Bridges
Curriculum Guide
Contains the materials from the second workshop on tech prep held in conjunction with the Work Now and in the Future conference series in Portland, Oregon. Topics include: private sector views on tech prep, results of a national study on planning and implementation, an ideal tech prep associate degree model, where to start, and in-depth sessions on tech prep.

375.24 SOUT 1991-1
Tech Prep Clusters
Report
Outlines the course sequence for high school tech prep program clusters. Includes accounting, data processing, graphic arts/printing, marketing, general office programs, agriculture, automotive, carpentry, drafting, electronics, horticulture, marine maintenance, masonry, plumbing, residential writing, sheet metal, welding, allied health, cosmetology, food service, mathematics/science, humanities, and practical nursing.

375.24 CAMP 1989-3
TECH PREP Compendium of Models
Report
Discusses the Delaware Consortium on Technical Preparation Programs or "Tech Prep." Describes how these programs can ease the transition to postsecondary education through entry to the Delaware Technical and Community College with advance standing. Includes a sample articulation agreement and models for business and industry, articulation, workshops, student progress, tech prep evaluation, and world of work.

375.24 BRAC 1990-1
Tech Prep Curriculum
Report
Provides a complete scope and sequence for tech prep students for the subjects of behavioral sciences, computer science, English, mathematics, and natural sciences. Includes the Tech Prep program philosophy goals, guidance section, and the curriculum schedule for business, allied health, engineering technology, and public services.

375.24 MOUN 1991-1
Tech Prep/Associate Degree Program Partnership Award Application
Report
Serves as a Tech Prep partnership award application packet submitted by Mt. Hood Community College District in Gresham, Oregon. Packet includes application, narrative description, support letters, documentary information, and sample articulation agreements. Documentary information includes an executive summary, newsletter, and 2+2 Tech Prep brochures in accounting, early childhood education, hospitality and tourism, office technology, manufacturing, and welding.

375.24 LUXF 1990-1
Technical Preparation Partnership Curriculum
Curriculum Guide
Contains the technical preparation sequence for electronics and the program guides in the Tech Prep 4 + 2 Associate Degree Program between Mason County Central High School and West Shore Community College.

375.24 CAMP 1989-1
TECH PREP Program Description Booklet
Report
Identifies the 2 + 2 TECH PREP programs that were started in Delaware as a result of a consortium that was formed to implement these programs. Also identifies the code number, location, instructor, enrollment, advanced credit earned, and the basic course content as developed by the United States Department of Education.

375.24 OKLA 1991-1
Tech Prep Program Development: Eastern Oklahoma County AVTS
Report
Defines vocational-technical education within Oklahoma. Includes a proposal for funding in the areas of instructor/counselor in-service training and parental involvement. Explores tech prep curriculum responsibilities and tech prep track versus general track education. Includes a list of basic competencies students should have attained for successful completion of technical programs at the two-year college level.

375.24 AAJC 1990-1
Tech Prep Program Descriptors
Report
Includes survey forms describing Tech-Prep programs in 34 states along with contact names, addresses and phone numbers.

375.24 SOUT 1991-2
TECH PREP (PREParation for TECHnologies)
Report
Explores the Tech-Prep program for Anderson, Oconee, and Pickens counties of South Carolina by defining the program, stating program goals, and listing expected outcomes and program management procedures. Discusses the PACE model for Tech Prep.

375.24 GRUB 1991-2
Tech-Prep Programs: Issues in Implementing the Carl Perkins Amendments of 1990
Report
Outlines issues and approaches to the implementation of the 1990 Perkins Amendments, specifically the Tech Prep Programs.

375.24 CAME 1988-1
Tech Prep Partnerships: Preparing Michigan Students for the Jobs of Tomorrow
Report
Discusses Michigan Tech Prep Associate Degree programs which are community-wide partnerships among school districts, community colleges, and business/labor to prepare youth and adults for entry into technical career fields. Appendices include Education Development Plan (EDP) models, general tech prep competencies, examples of organizational structures and examples of three associate degree programs.

621.38 LJTE 1991-1
Tech-Prep Programs: A Guide to Tech-Prep and Recommendations for Implementation
Textbook
Utilizes computer technology to both manage and deliver instruction in electronics. Outlines a recommendation for the design and implementation of a 4 + 2 tech-prep program in electronics/computer technology.

375.24 EAST 1990-1
Tech Prep Prospectus
Report
Serves as a prospectus for the Tech Prep program at East Central College in Union, Missouri in consortia with the surrounding schools. Explains what it is, why it is needed, what should a consortium do, what are the results, what about at-risk students, and how do schools participate. Also gives a principal's viewpoint.

375.24 BOYE 1991-1
Tech Prep: Curriculum Manual and Learning Activities
Curriculum Guide
Includes descriptions of ten projects for Grade 11 and nine projects for grade 12 used in the tech prep program. The projects are designed for students to work as members of a team in small groups and focus on integrating English, economics, math, science, computing, and manufacturing. Matrices are included which match specific content competencies with the projects. Includes guidelines for managing projects.

BEST COPY AVAILABLE

VT 375.24 NATI 1991-1
Tech Prep: Developing Cooperative Programs and Partnerships (Videotape)
Contains the proceedings of the Tech Prep teleconference originating from Blacksburg, Virginia on October 29, 1991. Five panelists discussed issues concerning the federal guidelines for Tech Prep, the elements necessary for a successful Tech Prep program, and the role of business/industry partnerships.

R 016.3714 MCFI 1991-1
Tech-Prep: A Bibliography
Reference Book
Bibliography shows how states are dealing with the work force crisis and provides examples of tech-prep articulation agreements. Articles by Marvin Feldman, Judith Marmaras, and Dale E. Thompson describe tech prep activities. Citations include guides, research reports, project descriptions, conference papers, and position papers.

375.24 HOER 1991-1
Tech Prep: A Viable Solution for the Forgotten Half
Report
Discusses the program elements of the work incentive model for tech-prep and shows how business/industry will participate.

375.24 MARY 1990-1
Tech Prep
Report
Focuses on the Tech Prep programs of Southern Maryland school systems and colleges. This coordinated sequence of academic and vocational courses, beginning in the ninth grade, prepares students for lifelong learning including advanced study at community colleges and technical institutions. Gives courses of study for 4+2 Advanced Technical Preparation. Also includes courses for Occupational Technology Preparation for apprenticeships and direct job entry.

375.24 SOUT 1990-2
Tech Prep: Southern Maryland Educational Consortium
Report
Informational packet for Southern Maryland Educational Consortium on Tech Prep includes pamphlets and information sheets from Calvert County Public Schools, Charles County Public Schools, St. Mary's County Public Schools, and Charles County Community College.

VT 375.24 ILLI 1991-1
TECH PREP: Planning for the 21st Century (Videotape)
Gives an overview of the Illinois Tech Prep program which addresses the employer's demand for a technically skilled workforce for the 21st century. This program starts at the 9th grade and progresses through postsecondary and beyond if desired. The program requires articulation between institutions, cooperation for education and employment and more emphasis on combining vocational and academic skills: math, science, and other basic skills.

375.24 CAMP 1989-2
TECH PREP Student Information Packet
Report
This packet includes a sample student letter, sample parent letter, sample letter awarding college credit, and a tech prep registration form. These sample letters and the form are used by the Delaware Consortium on Technical Preparation Programs. This program provides high school students an opportunity to earn advance college credits to the Delaware Technical and Community College while still in high school.

375.24 SASB 1985-1
Two-Plus-Two Articulation: A Guidebook for Educational Planning
Report
Presents some specific ideas and recommendations on articulation. This guide is concerned only with the last two years of high school and the way those two years fit into the two years of postsecondary education offered by community colleges and technical schools. Includes sample articulation agreements. Appendices consists of papers on articulation efforts in Pennsylvania, Illinois, and Virginia.

VT 331.118 CENT 1990-1
Transformations: Training for Technology (Videotape)
Promotes the Transformations program which provides retraining of employed workers and dislocated workers to upgrade their technical knowledge and skills so that they may better meet the needs of today's workplace. Training includes: using computers, technical graphics, interpersonal communications, mathematics in technology, principles of technology, electricity and electronics, hydraulic and pneumatic systems, and quality control.

375.24 KOLL 1987-1
Vocational Education Articulation Project Phase I
Report
Summarizes the results of a special project aimed at improving articulation between six feeder high school districts, the 49er Regional Occupational Program, Sierra College, and local businesses and industry. Discusses purpose and process, key themes and concepts, goals and objectives, strategies, and resources needed.

375.24 KENT 1989-1
Vocational Program Articulation and Cooperative Programming in Kentucky and Other States: A State-of-the-Art Report
Report
Summarizes articulation efforts in Kentucky through 1988. Focuses on comparison of course competencies in state vocational-technical schools and community colleges. Shows 15 vocational programs with credit ranging from 7 to 47 semester hours toward an associate degree. Gives articulation information for twelve other states. The appendix gives a list of contact persons for information on articulation.

375.24 NEIL 1990-1
VTAE/High School Articulation through TECH PREP
Report
Explains Wisconsin's VTAE (Vocational Technical Adult Education) school articulation "Tech Prep" program. Provides occupationally focused instruction for high school students who wish to enter the workforce, pursue technical careers in the military, and/or earn credit toward a Technical Associate Degree. Courses are based on a VTAE competency based curriculum. Students who successfully complete the course earn both high school credit and VTAE credit.

375.24 WASH 1990-1
Washtenaw County Public Schools and Washtenaw Community College From High School to College: Vocational Articulation in Washtenaw County
Report
Discusses the articulation procedure between Washtenaw County public schools and Washtenaw Community College in Michigan. Qualified vocational graduates who continue their studies at WCC may apply for equivalency credit for any of over thirty articulated courses.

375.24 SIER 1990-1
A Window into the Future. . .: How to Get Started in 2+2 Career-Vocational Education Articulation: Improving Access and Quality in Education for Community Colleges, High Schools, Regional Occupational Programs, and Adult Education
Report
Focuses on the 2 + 2 programs as a "window into the future" for all students. Explains how to get started in 2 + 2 career-vocational education articulation and how to improve access and quality in education for community colleges, high schools, regional occupational programs, and adult education. Includes agreement guidelines and agreement forms and a model agreement for clerical/secretarial/word processing.

375.24 SOUT 1989-1
The World of Technology: Articulation Program: The School District of Greenville County, Greenville Technical College
Report
Examines the articulation program that has been established between the School District of Greenville County and Greenville Technical College in South Carolina to help smooth the transition of high school graduates into higher education and employment in technical fields. Focuses on two types of articulation: Time-Shortened Articulation and Tech-Prep Cluster or Technical Preparatory Articulation.

375.22 CENT 1986-2
Writing Performance Objectives
Report
Gives brief information for writing performance objectives.

621.8 FCST 1991-1
Chicago Manufacturing Technical Preparation Program (Final Report)
Final Report
Final report for project to implement an industry-driven articulated four year manufacturing technology course of study that integrates applied academic courses with technical courses and meets industry hiring standards enabling students to obtain transferrable competencies.

BEST COPY AVAILABLE

375.24 JOHN 1991-1
Tech Prep Degree: Preparing Tomorrow's Workforce (Final Report)
Final Report
Final report for project between Black Hawk College and the Quad-City and Tri-County Vocational Regions to provide a TECH-PREP program where students will gain the academic course work required for higher education and the skills and attitudes needed in technological careers. Includes DACUM matrix of occupational competencies.

375.24 ROSS 1991-1
Tech Prep: Doing with Understanding (Final Report)
Final Report
Final report for project to develop a comprehensive information/orientation program to inform business, industry and education about Tech-Prep. Includes two plans compiled by Richard K. Hofstrand, Ph.D., Inservice Staff Development Plan and Equity/Access Student Attraction Plan.

630 LAW 1989-5
CORE Agricultural Education Curriculum: Horticulture Cluster
Curriculum Guide
Serves as an integrated curriculum for technical preparation (tech prep) in agriculture. Contains teaching units for the Horticulture Cluster problem areas. Includes: horticultural business operations, horticultural science and production, horticultural mechanics, landscaping, and floral design. Identifies student learning objectives which are related to the State Goals for Learning.

630 LAW 1989-4
CORE Agricultural Education Curriculum: Agricultural Business and Management Cluster
Curriculum Guide
Serves as an integrated curriculum for technical preparation (tech prep) in agriculture. Contains teaching units for Agricultural Business and Management Cluster problem areas. Includes: agribusiness, animal science, plant and soil science, food science and technology, and agricultural engineering/mechanization. Identifies student learning objectives which are related to the State Goals for Learning.

630 LAW 1989-3
CORE Agricultural Education Curriculum: Central Cluster
Curriculum Guide
Serves as an integrated curriculum for technical preparation (tech prep) in agriculture. Contains teaching units for the Central Core Cluster problem areas. Includes: agricultural literacy, generalizable skills in agricultural occupations, basic principles of agricultural science, agribusiness, leadership, and supervised experience in agriculture/horticulture. Identifies student learning objectives which are related to the State Goals for Learning.

BEST COPY AVAILABL

630 LAW 1990-2
CORE Agricultural Education Curriculum: Agricultural Resources Cluster
Curriculum Guide
Serves as an integrated curriculum for technical preparation (tech prep) in agriculture. Contains teaching units for the Agricultural Resources Cluster problem areas. Includes: environmental protection, forestry, fish and wildlife management, and outdoor recreation. Identifies student learning objectives which are related to the State Goals for Learning.

375.24 BPAG 1991-1
Illinois Tech Prep Planning Strategies
Report
This handbook is based on research gathered from 17 Illinois Tech Prep pilot sites. Discusses how to involve key groups in the planning process, program development, implementation and evaluation. An appendix includes a program profile for each of the 17 Tech Prep projects.

Appendix D

Indiana Department of Education, Vocational Education Section
Applied Curricula Sites
August 6, 1992

Listed below are school sites which are currently offering or planning to offer Applied Biology/Chemistry (ABC), Applied Communication (AC). Applied Mathematics (AM). Principles of Technology (PT), and Workplace Readiness: Education for Employment (WR) by the fall of the 1992-93 school year. The following codes designate the status of the sites and their primary method of instructional delivery:

D - Demonstration Site - received state funding, teacher(s) attended Indiana Department of Education coordinated inservice training, offered the applied curriculum for more than one year, and will serve as a valuable resource for newer sites needing assistance.

* - These sites have either implemented the indicated applied curriculum on their own initiative or will be implementing it in the fall of the 1992-93 school year.

CODES FOR PRIMARY METHOD OF INSTRUCTIONAL DELIVERY:

S - Stand alone course, taught by academic licensed teacher for academic credit.

IV - Infused with a vocational program to enhance basic skills, but not for academic credit.

IA - Infused with an academic course to enhance its occupational application and relevance.

Applied Curricula Sites / Contact Persons	ABC	AC	AM	PT	WR
Anthis Career Center, Fort Wayne Milt Eley, Coordinator in Industrial Technology Department				D/IV	
Bartholomew Consolidated School Corporation/Columbus Area Vocational School Meredith Thompson, Vocational Director		*	*	*	
Bedford North Lawrence Voc-Tech Center Don Piper, Vocational Director		D/S			

Benton Community School Corporation, Oxford Dale L. Jones, Vocational Director			*	*	
Blue River Career Programs, Shelbyville Robert Hobbs, Area Vocational Director			*		*
Carmel High School Mark Haltom, Industrial Technology Department Head Jack Mayfield, Science Department Head				*	
Center Grove High School, Greenwood James McAdams, Science Teacher	*				
Central Nine Voc-Tech School, Greenwood Larry Fosler, Assistant Director			*		*
Central Noble High School, Albion Kenneth Surber, Vocational Director		D/S			
Danville Community High School, Danville Maralee H. Edmondson, HERO Teacher-Coordinator					*
Delphi Community High School Robert Tyner, Mathematics Department Head			D/S		
Elkhart Area Career Center Clyde Riley, Principle			D/S		
Elkhart Memorial High School Jim Mayes, Mathematics Department Head			D/IA		
Fayette County School Corporation/ Connersville High School Robert Hoffman, Vocational Director		*	*	*	
Goshen High School Ken Horst, Teacher				*	
Hammond Area Vocational School John Jandura, Area Vocational Director					*
Heartland Career Center, Wabash Neal Pedro, Vocational Director		D/S	D/S		

Indiana Trails Coop./Twin Lakes High School, Monticello Dr. Kevin Caress, Principal Daniel Grayson, Area Vocational Director		*	*	*	*
Indianapolis Public Schools/Arsenal Technical High School Lewis Peterson, Job Placement		*	*		
Jefferson High School, Lafayette Connie Shoemaker, Jobs Coordinator					*
Kokomo Center Township Consolidated School Corporation Larry Foster, Vocational Director		*	*	*	
Mishawaka High School, Mishawaka Steve Clason, Tech Prep Coordinator					*
Monroe County Community School Corp./Hoosier Hills Area Vocational School, Bloomington Bruce Ricklin, Tech Prep Coordinator			*	*	
MSD Lawrence Township/Lawrence Central High School, Indianapolis Sue Kemmerer, Special Projects Director		D/IA	*		
MSD Lawrence Township/Lawrence North High School/McKenzie Career Center, Indianapolis Sue Kemmerer, Special Projects Director	*	D/IA	*		*
MSD Washington Township/J. Everett Light Career Center, Indianapolis Dr. Gary Oxenrider		D/S	D/S		
MSD of Wayne Township/Ben Davis High School, Indianapolis Ron Hoke, Vocational Director		*	*	*	
New Castle Community School Corporation Beverly Hankenhoff, Vocational Director		*	D/IV	*	

North Central Indiana Vocational Coop./ Plymouth High School Jerry Hollenbaugh, Vocational Director			*		
Owen Valley High School, Spencer Dan Cunningham, Principal	*				
Patoka Valley Vocational Coop./Northeast Dubois County School Corporation Harold L. Schipp, Vocational Director			*		
Patoka Valley Vocational Coop./Heritage Hills High School, Lincoln City Harold L. Schipp, Vocational Director				*	
Rensselaer Central High School, Rensselaer David Day, Principal					*
Scottsburg High School, Scottsburg Nina Vehslage, Science Teacher	*				
Seymour Senior High School, Seymour Jim McCormick, Principal		D/S	D/IA		
Shelbyville Central Schools/Blue River Career Programs, Shelbyville Robert Hobbs, Vocational Director		*	D/IV		
Southeastern Career Center, Versailles O. Eugene Pitts, Vocational Director		*	*		
Tipton High School, Tipton Robert Schultz, Principal					*
Vigo County School Corporation, Terre Haute Ken Pierce, Vocational Director		*	*	I/A	
Wabash High School, Wabash Neal Pedro, Vocational Director			D/S		
Wabash Valley Vocational Coop./South Vermillion High School Jerry Hawkins, Vocational Director		D/S	D/S	*	
West Central Indiana Vocational Coop./ Boone County Community School District Daniel Martin, Vocational Director			*		

West Central Indiana Vocational Coop./ MSD Warren County Daniel Martin, Vocational Director				*	
TOTAL NUMBER OF SITES	4	18	27	15	10

Applied Communication (AC) and Workplace Readiness: Education for Employment (WR) were developed by the Agency for Instructional Technology (AIT), Box A, Bloomington, IN 47402. Telephone (800) 457-4509 or (812) 339-2203.

Applied Mathematics (AM) 1 and 2 and Applied Biology/Chemistry (ABC) were developed by the Center for Occupational Research and Development (CORD), 601 C Lake Air Drive, Waco, TX 76710. Telephone (800) 231-3015.

Principles of Technology was jointly developed by AIT and CORD.

Appendix E

American Society for Training and Development. (1990). Workplace basics: The essential skills employers want. : Jossey-Bass.

Community Leaders Allied for Superior Schools. (undated). Blueprint 2005: What Indianapolis business desires of schools. Indianapolis: Author.

North Central Indiana Private Industry Council. (1992). Toward a new definition of employability. Peru, IN: Author.

Panel on Secondary School Education for the Changing Workplace. (1984) High schools and the changing workplace: The employers' view. Washington, D.C.: National Academy Press.

Secretary's Commission on Achieving Necessary Skills. (1991). What work requires of schools: A SCANS report for America 2000. Washington, D.C.: U.S. Department of Labor.

APPENDIX F

INDIANA VOCATIONAL TECHNICAL COLLEGE - NORTHCENTRAL
and
SCHOOL CITY OF MISHAWAKA

This agreement is made between Indiana Vocational Technical College - Northcentral and School City of Mishawaka.

The purpose of this agreement is to provide a mechanism for graduates of Mishawaka High School to articulate into post-secondary Applied Science, Business and Health Programs at Indiana Vocational Technical College - Northcentral. This agreement is in accordance with Title 511 - State Board of Education.

Mishawaka High School will offer the appropriate tech-prep curriculum model (general Tech-prep core and specialized courses), counsel students selecting the tech-prep program and retain records of competency validating completion of required courses for graduating.

Indiana Vocational Technical College - Northcentral will provide Mishawaka High School, on an annual basis, a list of current courses for which dual credit may be awarded.

Indiana Vocational Technical College - Northcentral will evaluate each student's record received from Mishawaka High School and award credit for courses designated as advanced standing where appropriate. The competencies of such courses will have been mutually agreed upon by the Division Chairs of the programs at Indiana Vocational Technical College - Northcentral and the Department Heads at Mishawaka High School.

All full time faculty and administration of both institutions will receive orientation on the articulation procedure and the courses described herein on an agreed upon schedule.

This agreement will be reviewed after the conclusion of each acadamic year by the Vice President/Chancellor of Indiana Vocational Technical College - Northcentral and the Superintendent of School City Mishawaka or their designees and it will remain in effect until modified or cancelled.

Vice President/Chancellor
Indiana Vocational Technical College - Northcentral

6-3-91
Date

Richard L. Brainerd
Superintendent
School City of Mishawaka

6-12-91
Date

Implementation Guidelines for the General Articulation Agreement

To provide for the implementation of the general articulation agreement between Indiana Vocational Technical College - Northcentral (hereafter referred to as the "College") and School City of Mishawaka, Mishawaka High School (hereafter referred to as the "High School"):

Mishawaka High School agrees to:

1 — Counsel students desiring to enter an applied science, business, or health technology program into the appropriate Tech-Prep curriculum.

2 — Retain records of competencies which validate completion of courses required for graduation.

3 — Make available to the students through the counselors and appropriate faculty the admission criteria for applied science, business, and health programs at the College.

4 — Provide the student through the counselors and appropriate faculty the listing of college courses which may be taken for dual credit (High School and College).

5 — In accordance with State Department of Education guidelines, encourage students to take advantage of dual credit courses for which they qualify.

6 — Annually provide for joint faculty dialogue and idea exchange for the purpose of review and enhancement of course content and competencies as deemed necessary by mutual agreement (High School and College).

7 — Provide the College Division Chairs with the current High School curriculum guide.

8 — Encourage students to take the pre-admission series in 1991, 1992 and 1993 for establishment of norms with a view to creating assessment criteria for admission into the applied science, business, and health programs in 1994.

9 — Provide the College with a list of students completing the Tech-Prep curriculum annually.

Indiana Vocational Technical College agrees to:

1 — Provide the High School with admission criteria for the interested Tech-Prep students.

2 — Provide the Tech-Prep students the opportunity to take the MAPS assessment in the Junior year, thereby allowing the student to strengthen necessary skills in the senior year prior to admission into the college.

3 — Provide dual credit courses for the students in the afternoon and early evening hours.

4 — Govern students enrolling in dual credit courses by the same polices as any student enrolling for specific course at the College.

5—Accept dual credit courses for application toward program requirements, providing matriculation into an applied science, business, or health technology program is completed with a period of five years.

6—Place courses completed for dual credit (High School and College) on the transcript at the completion of the semester in which they were attempted.

Courses which may be taken for dual credit in selected program areas are:

Applied Science Division

MTT 101	Machining Fundamentals
IMT 102	Introduction to Print Reading
IMT 120	Metallurgy Fundamentals
MTT 108	Precision Measurement
•AST 101	Chassis Suspension Principals
•AST 102	Two/Four Wheel Alignment
•AST 105	Fuel System
•AST 107	Engine Principle and Design
•ELT 113	Basic Electricity
••ELT 100	Circuits I
••ELT 102	Circuits Lab
••ELT 103	Digital Principles
••ELT 104	Computer Fundamentals for Technology
••AMT 101	Manufacturing Processes
••IMT 104	Fluid Power Basics
••AMT 102	Introduction to Robotics
•••DCT 102	Technical Graphics
•••DCT 103	CAD Fundamentals
•••DCT 109	Construction Materials Specifications (Architectural)

• Requires completion of Advanced Auto Mechanics I, II, III, and IV for dual credit registration.

••Requires completion of Electricity I and II for dual credit registration.

••• Requires Drafting I and II; and 2 semesters of the following: Drafting III, IV, or Drafting V, VI or Advanced Architectural Drafting I, II, III and IV or Advanced Mechanical Drafting I, II, III and IV to register for dual credit.

Business Technology Division

ACC 101	Accounting Principles I
AOT 214	Desktop Publishing
AOT 202	Advanced Word Perfect
AOT 104	Document Production
CIS 102	Data Processing Fundamentals

Health Technology Division

MEA 101	Medical Terminology
MEA 102	First Aid and CPR
PNU 103	Holistic Health
PNU 104	Nutrition
SCI 113	Anatomy and Physiology I
SCI 115	Anatomy and Physiology II

General Education Courses (taken at Ivy Tech)

SOC 102	Introduction to Psychology
ENG 101	English Composition

General Education Courses (taken at IUSB)

(Required courses for Associate of Science in Nursing at Indiana Vocational Technical College)

A 210	Elementary Human Anatomy
P 204	Elementary Human Physiology
W 131	Elementary Composition
P 103	General Psychology
P 236	Life Span Development Psychology
S 161	Principles of Sociology
M 110	Excursions into Mathematics

7 — Courses successfully completed in the Tech Prep curriculum in high school may entitle the student to advanced standing in the selected program. These courses will be placed on the transcript following successful completion of one semester of college work in the selected program area, provided matriculation into the college is attained no later than one semester following high school graduation.

Courses which may have credit by an advanced standing mechanism are:

Applied Science Division

Indiana Vocational Technical College Courses	Mishawaka High School Courses
DCT 101 Basic Drafting	Drafting I and II
DCT 102 Technical Graphics	Drafting III, IV, V and VI plus test out mechanism.
DCT 103 CAD Fundamentals	Drafting V, VI: Advanced Architectural Drafting I, II, III and V; Advanced Mechanical Drafting I, II, III and V plus test out mechanism.
MTT 101 Introduction to Machining	Machine Shop I and II plus test out mechanism.
AST Required Technical Courses	Advanced Auto Mechanics I, II, III and IV, interview required for test out possibilities of all first year courses.
ELT 100 Circuits I	Electricity I and II, plus test out mechanism.
ELT 102 Electronics Circuits	Electricity I and II plus Laboratory test out mechanism.
ELT 113 Basic Electricity	Electricity I and II plus test out mechanism.

Business Technology Division

ACC 101 Accounting Principles I	Accounting I, II, III and IV
AOT 100 Keyboarding	Keyboarding I
AOT 103 Information/Word Processing	Word Processing I, II and III
CIS 101 Intro to Micro	Computer Applications and Computer Programing

Health Technology Division

None at this time.

8—The preceding list of courses will be reviewed annually in the Fall Semester of each academic year. The faculty will provide the opportunity to review, revise and update the curriculum. Any impending changes in the curriculum plan (either high school or college) will be discussed for implementation. Class schedules times will be arranged for dual credit classes.

4-9-91

Appendix G

Complete References

Altman, T. (1992). Holography and interferometry. The Physics Teacher, 30, 220-223.

Alvarez, M. C. (1990, November). Case-based instruction and learning: An interdisciplinary project. Paper presented at the Annual Meeting of the College Reading Association, Nashville, TN.

Amatrol, Inc.. (1987). Basic pneumatics. Jeffersonville, IN: Author.

Amatrol, Inc. (1988). Basic hydraulics. Jeffersonville, IN: Author.

American Association for the Advancement of Science (1989). Project 2061: Science for all Americans. Washington D.C.: Author.

Agency for Instructional Technology (1988). Applied communication, module 11, (Making and responding to requests, 17-26.

Baker, G. (1971, January). Teach drafting through design analysis. School Shop.

Baker, G., Grubbs, B., & Barnhart, J. (1989). Mechatronics: Technology education's future. Industrial Education, 78(9), 18-21.

Bame, E. A., & Cummings, P. (1988). Exploring technology. Albany, NY: Delmar Publishers.

Belcher, C. (1991). Smoothing the rough spots. In D. Hull & D. Parnell (Eds.), Tech Prep associate degree: A win/win experience, 115-149. Waco, TX: Center for Occupational Research and Development.

Bellanca, J., & Fogarty, R. (1991). Blueprints for thinking in the cooperative classroom. Palatine, IL: Skylight Publishing.

Bellon, J.J., Bellon, E.C., & Blank, M.A. (1992). Teaching from a research knowledge base: A development and renewal process. New York: Macmillan.

Blank, William E. (1982). Handbook for developing competency-based training programs. Englewood Cliffs, NJ: Prentice Hall, Inc.

Bloom, B. S. (1956). Taxonomy of educational objectives. New York: David McKay.

Bloom, B. (1971). Mastery learning. In J. W. Block (Ed.), Mastery learning: Theory and practice. New York: Holt, Rinehart, and Winston.

658

Bruner, J. (1977). The process of education. Cambridge: Harvard University Press.

Butler, K.A. (1988). How kids learn: What theorists say about learning styles. Learning 88. 31-34.

Cackowski, F. (1991). Problem solving strategies. Paper presented at the meeting of the Indiana Industrial Technology Education (IITE) Conference, Hobart, IN.

Campbell, B. J. (1991). Planning for a student learning style. Journal of Education for Business, 66(6), 356-359.

Carnevale, A. P. (1990). Workplace basics: The essential skills employers want. Alexandria, VA: American Society for Training and Development.

Carroll, J. (1963). A model of school learning. Teachers College Record, 64, 723-733.

Cassell, S., & Sutley, A. (1991). A manual to facilitate the training of school personnel in the concepts and methodologies of the Indiana Tech Prep model. Unpublished training manual, Indiana Department of Education, Indianapolis, IN.

Chemical-Eating 'Bug' To The Rescue. (1990). USA Today, 118, No. 2541, p. 3.

Clarizio, H.F., Craig, R.C., & Mehrens, W.A. (1987). Contemporary issues in educational psychology (5th ed.). New York: Random House.

Clouse, B. (1985). Moral development: Perspectives in psychology and christian belief. Grand Rapids, MI: Baker Book House.

CNC Software Inc. (1992). Mastercam. Gig Harbor, WA: Author.

Costa, A.L. (1991). The school as a home for the mind. Palatine, IL: Skylight Publishing.

Court, D. (1991). Teaching critical thinking: What do we know? Social Studies, 82(3), 115-119.

Curry, L. (1990). Learning styles in secondary schools: A review of instruments and implications for their use. (Grant No. G-008690007-90). Madison, WI: University of Wisconsin, Center for Education Research. (ERIC Document Reproduction Service No. ED 317 283).

Davidson, G. V. (1990). Matching learning styles with teaching styles: Is it a useful concept in instruction? Performance and Instruction, 29(4), 36-38.

Davidson, N. (1989). Cooperative learning in mathematics: A handbook for teachers. Reading, MA: Addison-Wesley.

Delmar Publishers. (1974). Blueprint reading & sketching. Albany, NY: Author.

Dishon, D., & O'Leary, P. (1984). A guidebook for cooperative learning: A technique for creating more effective schools. Holmes Beach, FL: Learning Publications, Inc.

Dornsife, C. (1992). Beyond articulation: The development of Tech Prep programs. Berkeley, CA: National Center for Research in Vocational Education.

Dunn, R.S. (1983). You've got style--now's the time to find out what it is. Early years. 5, 25-31.

Eshed Robotic. (1982). Scorbot ERIII user's manual. Princeton, NJ: Author.

Eshed Robotic. (1989). Scorbot computer integrated manufacturing lab manual. Princeton, NJ: Author.

Finch, C.R. & Crunkilton, J.R. (1989). Curriculum development in vocational and technical education (3rd ed.). Boston: Allyn and Bacon, Inc.

Foyle, H. (1990). Cooperative learning--part 2: The classroom teacher. Kansas ASCD Record, 8(4).

Fullan, M., & Miles, M. (1992). Getting reform right: What works and what doesn't. Phi Delta Kappan, 73, 745-752.

Gallian, J.A., (1991). The mathematics of identification numbers. The College Mathematics Journal, 22, 194-202.

Gallian, J.A. and Winters, S. (1988). Modular arithmetic in the marketplace, American Mathematical Monthly 95, 548-551.

Gardner, M. (Ed.). (1991). Toward a scientific practice of science education. Hillside, NJ: Lawrence Erlbaum Associates.

Golub, J. (1988). Focus on collaborative learning. Urbana, IL: National Council of Teachers of English.

Green, I. (1988, August). How to choose a water filter. Popular Mechanics, 117-120.

Grubb, W., Davis, G., Lum, J., Plihal, J., & Morgaine, C. (1991). The cunning hand the cultured mind: Models for integrating vocational and academic education. Berkeley, CA: National Center for Research in Vocational Education.

Gumm, H.P., (1985). A new class of check digit methods for arbitrary number systems. IEEE Transactions on Information Theory 31, 102-105.

Gumm, H.P., (1986). Encoding of numbers to detect typing errors. International Journal of Applied Engineering Education, 2, 61-65.

Hacker, M., & Barden, R. (in press). Living with technology. Albany, NY: Delmar Publishers.

Hagar, H.A., Stewart, M.M., & Hutchinson, L.E. (1953). Business english and letter writing. New York: McGraw-Hill.

Hayes, J. R. (1981). The complete problem solver. Philadelphia: The Franklin Institute Press.

Herron, J.D., Agbebi, E., Cottrell, L., & Sills, T. (1976). Concept formation as a function of instructional procedures or what results from ineffective teaching. Science Education, 60, 375-388.

Herron, J.D., Cantu, L., Ward, R., & Srinivasan, V. (1977). Problems associated with concept analysis. Science Education, 61, 185-199.

Hiebert, J., & Carpenter, T.P. (1992). Learning and teaching with understanding. In D.A. Grouws (Ed.), Handbook of research on mathematics teaching and learning, 65-97. New York: Macmillan.

Hilgard, E.R., & Gordon, H.B. (1966). Theories of learning (3rd ed.). New York: Appleton-Century-Crofts.

Hoke, R., Competency based instruction, AVA Workshop, MSD Wayne Township, 1220 S. High School Road, Indianapolis, IN 46214.

Holmes, D., & Pardue, L. (1992, January/February). Confessions of a water planet. Consumer News.

Hull, D. (1991). Getting off the ground: The basics of developing a TPAD consortium. In D. Hull & D. Parnell. Tech Prep associate degree: A win/win experience. Waco, TX: The Center for Occupational Research and Development.

Hunt, David E. (1982). The practical value of learning styles ideas. National Association of Secondary School Principals. 87-91.

Indiana Association of Area Vocational Districts, Inc. (IAAVD). (1992). Competencies-based instruction. Speedway, IN: Author.

Indianapolis Department of Education (1991). Language arts proficiency guide. Unpublished draft curriculum document, Indianapolis, IN.

International Association for the Study of Cooperative Learning Newsletter. Editors, N. & T. Graves. Santa Cruz, CA.

Jacobs, Harold R. (1982). Mathematics: A human endeavor, San Francisco: W. H. Freeman Company, 378-409, 510-517.

Johnson, D. W., & Johnson, R.T. (1987). Learning together alone: Cooperative, competitive, and individualistic. Englewood Cliffs, NJ: Prentice-Hall.

Joint Committee on Standards for Educational Evaluation. (1981). Standards for evaluation of educational programs, projects, and materials. New York: McGraw Hill.

Keefe, J. W. (1986). Assessment of learning style variables: The NASSP task force model. Theory Into Practice, 24(2), 138-144.

Klausmeier, H., Ghatala, E., & Frayer, D. (1974). Cognitive learning and development: A cognitive view. New York: Academic Press.

Kliebard, H.M. (1987). The struggle for the American curriculum,1893-1958. New York: Routledge.

Kloosterman, P., & Gainey, P.H. (in press). Students' thinking: Middle school mathematics. In D. Owens (Ed.), Research ideas for the classroom: Middle grades mathematics. New York: Macmillan.

Knill, G. (1981). International Standard Book Numbers, Mathematics Teacher 74, 47-48.

Koberg, D., & Bagnall, J. (1981). The revised all new universal traveler. Los Altos, CA: William Kaufmann, Inc.

Komacek, S.A. (in press). Production technology. Albany, NY: Delmar Publishers.

Latham, R. (1986, October). Holography in the science classroom. The Physics Teacher, 395-400.

Lefrancois, G.R. (1988). Psychology for teaching (6th ed.). Belmont, CA: Wadsworth Publishing Co.

Linthwaite, M. and Shimmens, C. (1987, September). Simple method of producing good-quality holograms without the need for expensive equipment. The Physics Teacher, 382-3.

Louis, K., & Mles, M. (1990). Improving the urban high school: What works and why. New York: Teachers College Press.

Lundsteen, S. W. (1986, November). Critical thinking in problem solving: A perspective for the language arts teacher. Paper presented at the Annual Meeting of the National Council of Teachers of English, San Antonio, TX.

Lunetta, V. N. (1990). Cooperative learning in science, mathematics, and computer problem solving. In M. Gardner (Ed.), Toward a scientific practice of science education, 235-249. Hillsdale, NJ: Lawrence Earlbaum Associates.

Mager, R. F. (1975). Preparing instructional objectives (rev. ed.). Belmont, CA: Fearon-Pitman

Publishers.

Macmillan english 12: Thinking and writing processes. (1988). New York: Scribner Laidlaw, 241.

Mergendoller, J.R., & Marchman, V.A. (1987). Friends and associates. In V. Richardson-Koehler (Ed.), Educators'handbook: A research perspective, 297-328. New York: Longman.

Miller, J.P., & Seller, W. (1985). Curriculum: Perspectives and practice. New York: Longman.

Miller, R., & Culpepper, F. (1991). Electricity and electronics. Albany, NY: Delmar Publishers.

Mueller, W. (July, 1988). A guide to water purifiers. Consumers Research Magazine, 11-17.

National Assessment Governing Board (May 31, 1991). 1994 NAEP assessment framework. Council of Chief State School Officiers, 379 Hall of the States, 400 North Capital St., N.W., Washington, D.C. 20001-1511: Author. Quoted in 1991).ASCD curriculum handbook. Alexandria, VA: Association for Supervision and Curriculum Development, 5.12-5.13.

National Council for Teachers of Mathematics (1989). Curriculum and evaluation standards for school mathematics. 1906 Association Drive, Reston, VA 22091: Author.

National Science Teachers Association (1990). Project on scope, sequence and coordination of secondary school science. Washington, D.C.: Author.

Nelms, B. F. (1990). Cooperative learning in English (The round table). English Journal, 76(6), 74-77.

O'Neil, J. (1990). Making sense of style. Educational Leadership, 48(2), 4-9.

On tap: Safe drinking water. (April, 1988). Current Health 2. 16-18.

Padden, H. (1991). 2+2+2 equals college credit in California. In D. Hull & D. Parnell (Eds.), Tech Prep associate degree: A win/win experience, 179-189. Waco, TX: Center for Occupational Research and Development.

Parnell, D. (1985). The neglected majority. Washington, D.C.: Community College Press.

Paul, R., Binker A. J. A., Martin, D., & Adamson, K. (1989). Critical thinking handbook: High school. Rohnert Park, CA: Sonoma State University, Center for Critical Thinking and Moral Critique. (ERIC Document Reproduction Service No. ED 325 805).

Pearson, P. D. (1991). Assessing literacy. Salt Lake City: Utah State Reading Council.

Peck, L.C. (1975). Secret codes, remainder arithmetic and matrices. Reston, VA: National Council of Teachers of Mathematics, 1-11, 29-35.

Pedrotti, L., & Parks, D. (1991). A solid foundation: The role of applied academics. In D. Hull & D. Parnell, Tech Prep associate degree: A win/win experience. Waco, TX: The Center for Occupational Research and Development.

Polya, G. (1957). How to solve it: A new aspect of mathematical method (2nd ed.). Princeton, NJ: Princeton University Press.

Resnick, L. (1987). Education and learning to think. Washington, D.C.: National Academy Press.

Sanders, M., & LaPorte, J. (1991). T/S/M integration project. Technology/Science/Math Integration Project funded by the National Science Foundation.

Sawyer, D. E. (1986). Hands-on labs in an academic high school. Vocational Education Journal, 61(4), 50-52.

Schwartz, J. (1989, February 27). Cleaning up by cleaning up. Newsweek, 53.

Scriven, M.S. (1983). Evaluation ideologies. In G.F. Madaus, M.S. Scriven, & D.L. Stufflebeam (Eds.), Evaluation models: Viewpoints on educational and human services evaluation, 229-260. Norwell, MA: Kluwer Academic Publishers.

Secretary's Commission on Achieving Necessary Skills. (1991). What work requires of schools: A SCANS report for America 2000. Washington, DC: U.S. Department of Labor. (ERIC Document Reproduction Service No. ED 332 054).

Slavin, R. E. (1991). Synthesis of research on cooperative learning. Educational Leadership, 48(5), 71-82.

Southern Regional Education Board (SREB) State Vocational Education Consortium. (1992). Making high school work: Adding purpose and focus to secondary schools through integration of academic and vocational education. Draft report prepared by the State Vocational Education Consortium, Atlanta, GA.

Steen, L. A. (1989). Teaching mathematics for tomorrow's world. Educational Leadership, 7(1), 18-22.

Stein, J. (Ed.). The Random House college dictionary (Rev. Ed.). New York: Random House.

Stufflebeam, D.L. (1983). The CIPP model for program evaluation. In G.F. Madaus, M.S. Scriven, & D.L. Stufflebeam (Eds.), Evaluation models: Viewpoints on educational and human services evaluation, 117-141. Norwell, MA: Kluwer Academic Publishers.

Supplying Our Water Needs. (1988). CHEMCOM: Chemistry in the community. Kendall/Hunt Publishing Company.

Tevis, C., & Freese, B. (December, 1988). Water treatment systems. Successful Farming, 40-41.

Thornton, D.S. (1983). Check out UPCs. 80 Micro 46, 114-120.

Tobias, S. (1990). They're not dumb, they're different: Stalking the second tier. Tucson, AZ: Research Corporation.

Walker, D.F., & Soltis, J.F. (1986). Curriculum and aims. New York: Teachers College Press.

Webb, N. (1985). Verbal interaction and learning in peer-directed groups. Theory Into Practice, 24(1), 32-39.

Webendorfer, B. (September, 1988). A drop to drink. Country Journal. 27-33.

Wentling, T.L. (1980). Evaluating occupational education and training programs. Urbana, IL: Griffon Press.

Wolf, R.A. (1984). Evaluation in education: Foundations of competency assessment and program review (2nd ed.). New York: Praeger Publishers.

Wood, E.F. (1987). Self-checking codes--an application of modular arithmetic, Mathematics Teacher 80, 312-316.

Video

Modern. (1990). Race against time [videotape]. St. Petersburg, FL: Distributor.

Modern. (1991). The challenge of manufacturing [videotape]. St. Petersburg, FL: Distributor.

*Delmar Publishers, 2 Computer Dr. West, Box 15-015, Albany, NY 12212-5015.

*CNC Software Inc., 2909 71st. Ave. N.W., Gig Harbor, WA 98335.

*Amatrol Inc., PIO. Box 2697, Jeffersonville, IN 47131.

*Eshed Robotic, 445 Wall St., Princeton, NJ 08540.

*Modern, 5000 Park St. North, St. Petersburg, FL 33709.